

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE

Interim Measure/Interim Remedial Action (IM/IRA) Decision Document for the Present Landfill

at the

Rocky Flats Environmental Technology Site
10808 Highway 93
Golden, CO 80403-8200

Draft

June 20, 2002

This document is a WORKING DRAFT, which means it is undergoing concurrent review by K-H, DOE, EPA, and CDPHE legal, regulatory, and technical staff. It is being distributed at this stage to allow for informal stakeholder input and consultation.

Reviewers should note that Section 2.9, Nature and Extent of Contamination, is being evaluated by K-H technical staff and may be replaced with a new section that includes an analysis of recent data collected in accordance with the Site Integrated Monitoring Program, in addition to the existing summary of results from previous remedial investigations.



Reviewed for Classification/UCNI:
DOCUMENT CLASSIFICATION REVIEW
WAIVER PER CLASSIFICATION OFFICE
WAIVER NO. CEX-105-01

ARMED RECHN

OU07-A-000532

1/102

RECORD OF MODIFICATIONS

Modification #	Effective Date	Description

This document is a WORKING DRAFT, which means it is undergoing concurrent review by K-H, DOE, EPA, and CDPHE legal, regulatory, and technical staff. It is being distributed at this stage to allow for informal stakeholder input and consultation.

Reviewers should note that Section 2.9, Nature and Extent of Contamination, is being evaluated by K-H technical staff and may be replaced with a new section that includes an analysis of recent data collected in accordance with the Site Integrated Monitoring Program, in addition to the existing summary of results from previous remedial investigations.

2

TABLE OF CONTENTS

ACRONYMS AND ABBREVIATIONS	vi
EXECUTIVE SUMMARY	1
1.0 INTRODUCTION	2
2.0 BACKGROUND	4
2.1 OPERATIONAL HISTORY	4
2.2 INTERIM RESPONSE ACTIONS	6
2.3 GEOLOGIC SETTING	7
2.3.1 GENERAL GEOLOGIC FRAMEWORK	8
2.3.2 DESCRIPTION OF GEOLOGIC UNITS	8
2.3.3 DISTRIBUTION OF GEOLOGIC UNITS	9
2.3.4 LANDFILL POND SEDIMENTS	10
2.4 HYDROGEOLOGIC SETTING	10
2.4.1 UPPERMOST AQUIFER	10
2.4.2 POTENTIOMETRIC SURFACE	11
2.4.3 VERTICAL HYDRAULIC GRADIENTS	11
2.4.4 GROUNDWATER FLOW VELOCITIES	12
2.5 CONCEPTUAL FLOW MODEL	12
2.5.1 SURFACE WATER HYDROLOGY	14
2.5.2 INTERACTIONS BETWEEN SURFACE WATER & GROUNDWATER	15
2.5.3 GROUNDWATER HYDROLOGY	16
2.6 METEOROLOGY & AIR QUALITY	17
2.7 ECOLOGICAL RESOURCES	18
2.8 SURROUNDING LAND USE & POPULATION	18
2.9 NATURE AND EXTENT OF CONTAMINATION	18
2.9.1 LANDFILL GAS	20
2.9.2 LANDFILL LEACHATE AT THE SEEP	20
2.9.3 SURFACE WATER IN THE LANDFILL POND	21
2.9.4 SEDIMENTS IN THE LANDFILL POND	21
2.9.5 SUBSURFACE GEOLOGIC MATERIALS DOWNGRAIENT OF THE LANDFILL	21
2.9.6 GROUNDWATER DOWNGRAIENT OF THE PRESENT LANDFILL	21
3.0 PROJECT APPROACH	24
3.1 COVER DESIGN ALTERNATIVES	24
3.2 PROJECT PLANNING & EXECUTION	28
3.2.1 MOBILIZATION	28
3.2.2 SITE PREPARATION	28
3.2.3 GAS-VENTING/BIOTA LAYER PLACEMENT	29
3.2.4 SOIL EXCAVATION, PROCESSING, AND TRANSPORTATION	30

3.2.5	SOIL PLACEMENT	30
3.2.6	PASSIVE SEEP TREATMENT SYSTEM	31
3.2.7	PERFORMANCE MONITORING EQUIPMENT	31
3.2.8	REVEGETATION	31
3.2.9	SITE CLEANUP AND DEMOBILIZATION	31
3.3	PROJECT CONTROLS	31
3.3.1	INTEGRATED WORK CONTROL	32
3.3.2	READINESS DETERMINATION	32
3.3.3	QUALITY ASSURANCE	32
3.3.4	CONDUCT OF OPERATIONS	32
3.3.5	WORKER HEALTH & SAFETY	32
3.3.6	EMERGENCY PREPAREDNESS	33
3.3.7	ENVIRONMENTAL MANAGEMENT	33
3.3.8	WASTE MANAGEMENT	33
3.4	WORKING RELATIONSHIPS	34
4.0	RCRA UNIT CLOSURE	35
4.1	NOTIFICATION OF CLOSURE	35
4.2	CLOSURE ACTIVITIES	35
4.3	CLOSURE DOCUMENTATION	35
5.0	POST-CLOSURE CARE	36
5.1	INSTITUTIONAL CONTROLS	36
5.2	MONITORING & MAINTENANCE	36
5.2.1	GROUNDWATER MONITORING	36
5.2.2	GAS VENT MONITORING	39
5.2.3	SURFACE WATER MONITORING	39
5.2.4	PERFORMANCE MONITORING	40
5.2.5	INSPECTION AND MAINTENANCE	42
5.2.6	ADDITIONAL MONITORING AND EVALUATION ACTIVITIES	44
5.3	PERFORMANCE ASSESSMENT & REPORTING	45
5.4	CORRECTIVE MEASURES	45
5.5	CERCLA FIVE-YEAR REVIEWS	46
6.0	ENVIRONMENTAL CONSEQUENCES	47
6.1	IMPACTS TO AIR QUALITY	47
6.1.1	POTENTIAL FUGITIVE DUST EMISSIONS	47
6.1.2	POTENTIAL METHANE EMISSIONS	48
6.2	IMPACTS TO SURFACE WATER	48
6.3	IMPACTS TO GROUNDWATER	49
6.4	IMPACTS TO WILDLIFE & VEGETATION	50
6.5	IMPACTS TO TRANSPORTATION	51
6.6	IMPACTS TO CULTURAL & HISTORIC RESOURCES	51
6.7	IMPACTS TO VISUAL RESOURCES	52
6.8	NOISE IMPACTS	52
6.9	CUMULATIVE IMPACTS	52
6.10	IRREVERSIBLE & IRRETRIEVABLE COMMITMENT OF RESOURCES	52

4

7.0 LONG-TERM STEWARDSHIP	54
7.1 ENGINEERED CONTROLS	54
7.2 INSTITUTIONAL CONTROLS	55
7.3 MONITORING & MAINTENANCE	55
7.4 INFORMATION MANAGEMENT	56
7.5 PERIODIC ASSESSMENTS	57
7.6 CONTROLLING AUTHORITY	58
8.0 APPLICABLE OR RELEVANT & APPROPRIATE REQUIREMENTS	59
8.1 RCRA UNIT CLOSURE	59
8.2 AIR	60
8.3 WATER	60
8.4 SOLID WASTE	60
8.5 WETLANDS	60
8.6 WILDLIFE	61
8.7 MINERAL RESOURCES	61
9.0 IMPLEMENTATION SCHEDULE	62
10.0 CLOSEOUT REPORT	63
11.0 COMMENT RESPONSIVENESS SUMMARY	64
12.0 REFERENCES	65

APPENDICES

APPENDIX A – ENVIRONMENTAL QUALITY DATA FOR THE PRESENT LANDFILL	A-1
APPENDIX B – APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS.....	B-1
APPENDIX C – PRESENT LANDFILL IM/IRA IMPLEMENTATION SCHEDULE	C-1
APPENDIX D – COMMENT RESPONSIVENESS SUMMARY.....	D-1

LIST OF FIGURES

FIGURE 1.	ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE.....	3
FIGURE 2.	PRESENT LANDFILL.....	5
FIGURE 3.	PRESENT LANDFILL WELLS.....	13
FIGURE 4.	RCRA GROUNDWATER MONITORING DECISION TREE.....	38

LIST OF TABLES

TABLE 1.	COMPARISON OF DESIGN ALTERNATIVES.....	25
TABLE 2.	SEEP TREATMENT SYSTEM WATER ANALYTES AND PERFORMANCE STANDARDS	40
TABLE A-1.	ANALYTES DETECTED IN LEACHATE AT THE SEEP	A-2
TABLE A-2.	ANALYTES DETECTED IN EAST LANDFILL POND SURFACE WATER	A-5
TABLE A-3.	ANALYTES DETECTED IN EAST LANDFILL POND SEDIMENTS	A-7
TABLE A-4.	ANALYTES DETECTED IN SUBSURFACE GEOLOGIC MATERIALS DOWNGRAIENT OF PRESENT LANDFILL	A-9
TABLE A-5.	ANALYTES DETECTED IN UPPER HYDROSTRATIGRAPHIC UNIT GROUNDWATER DOWNGRAIENT OF PRESENT LANDFILL	A-12
TABLE A-6.	ANALYTES DETECTED IN LOWER HYDROSTRATIGRAPHIC UNIT GROUNDWATER DOWNGRAIENT OF PRESENT LANDFILL	A-15
TABLE A-7.	SUMMARY OF GROUNDWATER QUALITY DATA FOR PRESENT LANDFILL WELLS	A-17
TABLE A-8.	GROUNDWATER QUALITY ANALYTES AND RFCA EXCEEDANCES	A-18

ACRONYMS AND ABBREVIATIONS

ACAP	Alternative Cover Assessment Program
ACM	asbestos-containing material
ALF	Action Level Framework
ANSI	American National Standards Institute
APEN	Air Pollutant Emission Notice
ARAR	applicable or relevant and appropriate requirement
BZ	Buffer Zone
CAD	Corrective Action Decision
CDPHE	Colorado Department of Public Health and Environment
CDR	Conceptual Design Report
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CGI	combustible gas indicator
CHWA	Colorado Hazardous Waste Act
CID	Cumulative Impacts Document
COOP	Conduct of Operations
CPB	Closure Project Baseline
CQC	Construction Quality Control (Plan)
CSI	Construction Specification Institute
CY	calendar year
DOE	U.S. Department of Energy, Rocky Flats Field Office
DOI	U.S. Department of the Interior
EPA	U.S. Environmental Protection Agency
ER	Environmental Restoration (Program)
EROP	ER Operations Plan
ESS	Environmental Systems & Stewardship
ET	evapotranspiration
FY	fiscal year
GAC	granular activated carbon
gpm	gallons per minute
GWIS	groundwater interceptor system
HAP	hazardous air pollutant
HASP	Health & Safety Plan
IA	Industrial Area
IGD	Implementation Guidance Document
IHSS	Individual Hazardous Substance Site
IM/IRA	Interim Measure/Interim Remedial Action

IMP	Integrated Monitoring Plan
ISMS	Integrated Safety Management System
IWCP	Integrated Work Control Program
LHSU	lower hydrostratigraphic unit
LRA	Lead Regulatory Agency
MAR	Management Assessment of Readiness
MCL	Maximum Contaminant Level
mg/L	milligrams per liter
µg/L	microgram per liter
mrem	millirem
NAAQS	National Ambient Air Quality Standard
NCP	National Contingency Plan
NEPA	National Environmental Policy Act
NMOC	non-methane organic compound
NPDES	National Pollutant Discharge Elimination System
NW	northwest
OSHA	Occupational Safety & Health Act
OS&IH	Occupational Safety & Industrial Hygiene
OU	Operable Unit
PAC	Potential Area of Concern
PCBs	polychlorinated biphenyls
PCOC	potential contaminant of concern
PID	photoionization detector
PM ₁₀	particulate matter with an aerodynamic diameter less than or equal to 10 micrometers
PPE	personal protective equipment
PPRG	Programmatic Preliminary Remediation Goal
PU&D	Property Use & Disposition
QA	quality assurance
QC	quality control
RADMS	Remedial Action Decision Management System
RCRA	Resource Conservation and Recovery Act
RFCA	Rocky Flats Cleanup Agreement
RFETS	Rocky Flats Environmental Technology Site
RFI/RI	RCRA Facility Investigation/Remedial Investigation
RISS	Remediation, Industrial Area, and Site Services (Project)
ROD	Record of Decision
SRA	Support Regulatory Agency
SVOC	semi-volatile organic compound
SWD	Soil Water Database

8

TOC	total organic carbon
TOX	total organic halogen
UBC	Under Building Contamination
UHSU	upper hydrostratigraphic unit
USFWS	U.S. Fish and Wildlife Service
VOC	volatile organic compound

EXECUTIVE SUMMARY

This Interim Measure/Interim Remedial Action (IM/IRA) decision document presents the proposed interim remedial action for the Present Landfill at the U.S. Department of Energy's (DOE's) Rocky Flats Environmental Technology Site (RFETS or Site) in Golden, CO.

The Present Landfill is located in the RFETS Buffer Zone (BZ), north of the Industrial Area (IA). The landfill was operated from 1968 to 1998, primarily as a solid waste disposal facility. The landfill was used for office trash, paper, rags, personal protective equipment, construction and demolition debris, scrap metal, empty waste containers, used filters, and electrical components. Historically, the landfill also received materials containing polychlorinated biphenyls (PCBs); combustible materials contaminated with small amounts of beryllium particulate matter; hazardous waste streams such as paints, solvents, and foam polymers; asbestos containing material (ACM); and sludge contaminated with radionuclides.

The Present Landfill is a Resource Conservation and Recovery Act (RCRA) interim status unit, which is being closed in accordance with the Rocky Flats Cleanup Agreement (RFCA) (DOE, CDPHE, EPA 1996) and the applicable closure/post-closure requirements of the RCRA and Colorado Hazardous Waste Act (CHWA). The U. S. Environmental Protection Agency (EPA) is the Lead Regulatory Agency (LRA) for the BZ, and is thus the LRA for remediation of the Present Landfill. The Colorado Department of Public Health and Environment (CDPHE) is the Support Regulatory Agency (SRA) for the BZ, but has primary responsibility for RCRA closure activities. As a result, both CDPHE and EPA will oversee the planning and implementation of the proposed remedial action.

Closure requirements for the Present Landfill will be met by constructing an evapotranspiration (ET) cover that relies on the natural processes of soil moisture storage and plant uptake of moisture to minimize or eliminate infiltration of precipitation through the cover. The performance specifications presented in this IM/IRA will dictate the final design of the ET cover. A conceptual design has been completed for the ET cover, reflecting these requirements (K-H 2002a). The final design is scheduled to be completed during fiscal year (FY) 2002.

The proposed action will be planned and executed in accordance with the RFETS Integrated Safety Management System (ISMS), which provides the framework for ensuring that all work performed at RFETS is planned, analyzed, reviewed, approved, and performed safely. ISMS is implemented through a variety of existing sitewide programs that have been designed to protect worker health and safety and the environment.

A phased program of monitoring and maintenance will be implemented to ensure the integrity of the ET cover, and to assess its performance over a 30-year period.

In accordance with Paragraph 95 of RFCA, National Environmental Policy Act (NEPA) values have been incorporated to satisfy the requirement for a "NEPA equivalency" assessment of environmental consequences from the proposed action.

1.0 INTRODUCTION

This IM/IRA decision document presents the proposed interim remedial action for the Present Landfill at RFETS. The landfill is a RCRA interim status unit, which must be closed in accordance with Attachment 10 to RFCA and the applicable closure/post-closure requirements of RCRA and the CHWA. The proposed remedy consists of an ET cover, which relies on the natural processes of soil moisture storage and plant uptake of moisture to minimize or eliminate infiltration of precipitation through the cover.

EPA is the LRA for the BZ, and is thus the LRA for remediation of the Present Landfill. CDPHE is the SRA for the BZ, but has primary responsibility for RCRA closure activities. As a result, both CDPHE and EPA will oversee the planning and implementation of the proposed remedial action.

RFETS is a government-owned, contractor-operated facility in the nationwide nuclear weapons production complex. The Site is located on approximately 6,550 acres in northern Jefferson County, Colorado, 16 miles northwest of Denver. Major buildings are located within the 400-acre IA, which is surrounded by a 6,150-acre BZ, (Figure 1). Facility operations began in 1952, with the primary mission to produce nuclear weapons components from plutonium, uranium, beryllium, and stainless steel. Support activities included chemical recovery and purification of recyclable transuranic radionuclides, and research and development in metallurgy, machining, nondestructive testing, coatings, remote engineering, chemistry, and physics.

With suspension of nuclear weapons production operations at the Site in 1989, and subsequent discontinuation of the production mission in 1992, facility operations were re-directed to support accelerated Site closure, including decommissioning, waste management, and environmental restoration (ER) activities at the Site's Individual Hazardous Substance Sites (IHSSs), Potential Areas of Concern (PACs), and Under Building Contamination (UBC) sites. Site closure activities are being conducted in accordance with RFCA (DOE, CDPHE, EPA 1996), which provides the regulatory framework for achieving accelerated cleanup and closure in a manner that is safe to workers and the public, and protective of the environment.

A Phase I RCRA Facility Remedial Investigation/Remedial Investigation (RFI/RI) was conducted in 1992 and 1993 to characterize the site features at the Present Landfill, and to make preliminary determinations of the sources of contamination, and the nature and extent of contamination. The Phase II RFI/RI was conducted in 1994 and 1995 to further define the nature and extent of contamination and to support the development of an IM/IRA. A draft Phase I IM/IRA and Closure Plan document was prepared in 1996 (DOE 1996), concurrent with the negotiation of RFCA. Attachment 4 to the Final RFCA contained a prioritized list of remedial actions for the Site, which placed the Present Landfill at number 18 of the top 50 sites requiring remediation. As a result, the 1996 draft IM/IRA was abandoned, and resources and funding were reallocated to sites ranked higher on the list. This IM/IRA is based on the information contained in the 1996 draft IM/IRA, as well as the conceptual design for the landfill cover (K-H 2001a) and data collected as part of the ongoing Site Integrated Monitoring Program.

The scope of this IM/IRA is limited to construction of the Present Landfill cover to close the RCRA interim status unit. A groundwater remedy will not be proposed at this time because it is unknown if the landfill is impacting groundwater. Although impacts to groundwater upgradient of the landfill have been documented, and some anomalous results have been noted for groundwater downgradient of the landfill, the chemistry of the contamination downgradient of the landfill is inconsistent with the contamination originating in the landfill seep. Therefore, while the landfill cover design is being completed, the operability of the existing groundwater interceptor system will be investigated and groundwater data will be analyzed to determine whether a groundwater remedy is needed. If a groundwater remedy is required, this IM/IRA will be modified in accordance with Part 10 of RFCA.

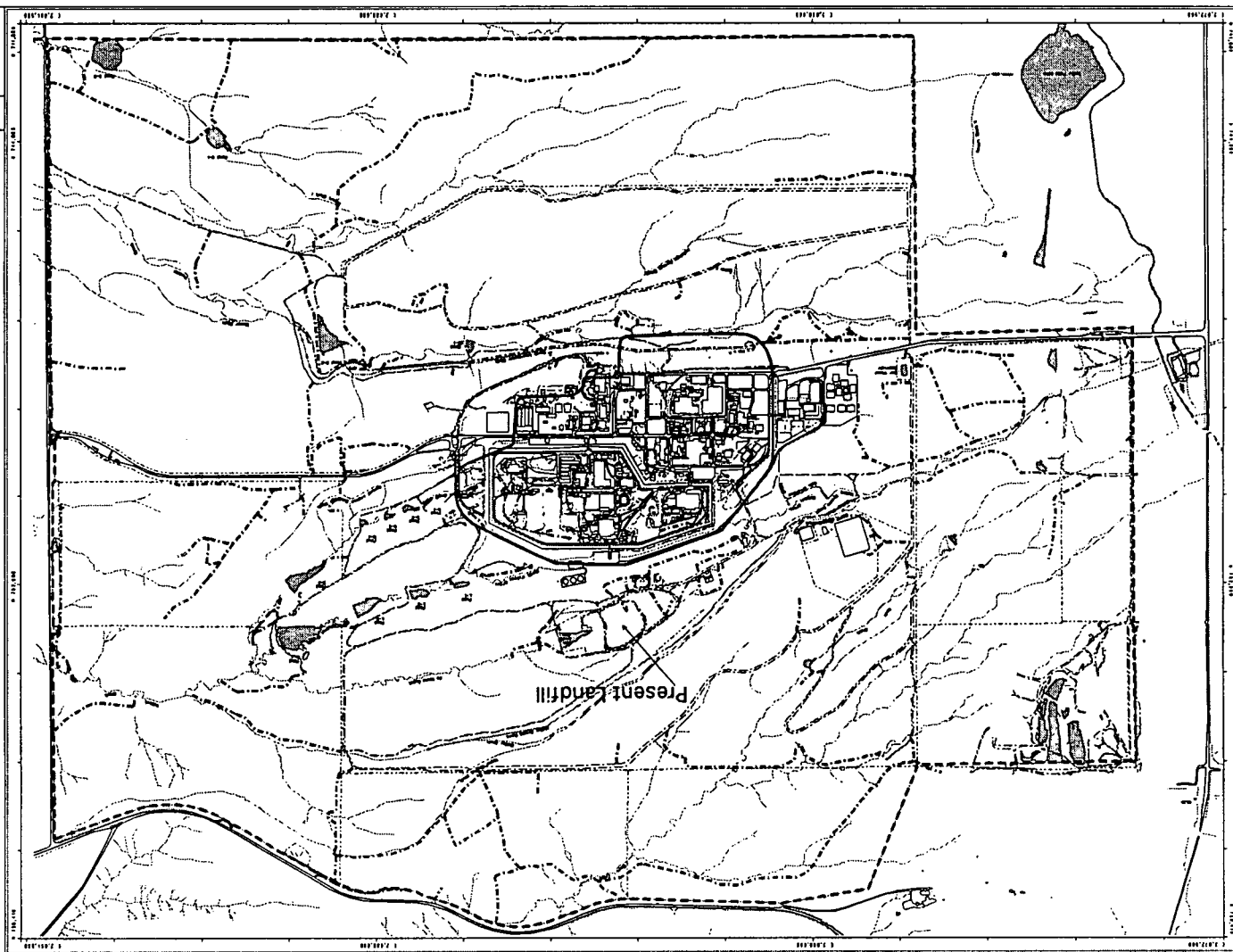


Figure 1
Rocky Flats Environmental
Technology Site

EXPLANATION

- N Industrial Area Boundary
- N Buffer Zone Boundary

Standard Map Features

- Buildings and other structures
- Leas and ponds
- Drainage ditches or other
- Drainage features
- Fences and other barriers
- Paved roads
- Dirt roads

DATA SOURCE: BASE FEATURES:
 Digital Line, Point, Polygon, Area and other
 features from 1:250,000 scale map and
 other sources. Data was digitized from
 1:250,000 scale map and other sources.
 Data source: 1:250,000 scale map and
 other sources. Data was digitized from
 1:250,000 scale map and other sources.
 Data source: 1:250,000 scale map and
 other sources. Data was digitized from
 1:250,000 scale map and other sources.

Scale = 1 : 35,400
 1 inch represents 2,950 feet

State Plane Coordinate Projection
 Datum: NAD 83
 Colorado Central Zone

U.S. Department of Energy
 Rocky Flats Environmental Technology Site

Prepared by:
DynCorp
 Prepared for:
 U.S. Department of Energy
 Rocky Flats Environmental Technology Site
 Date: 04/16/2002

2.0 BACKGROUND

The Present Landfill is part of Operable Unit (OU) 7, which is comprised of a series of IHSSs and PACs located north of the IA, at the western end of No Name Gulch drainage (Figure 2). These include the Present Landfill (IHSS 114), the Landfill Pond Spray Areas (IHSSs 167.2 and 167.3), Inactive Hazardous Waste Storage Area (IHSS 203), Improper Disposal of Diesel-Contaminated Material at Landfill (PAC-NW-1502), Improper Disposal of Fuel-Contaminated Material at Landfill (PAC NW-1503), and Improper Disposal of Thorosilane-Contaminated Material at Landfill (PAC NW-1504). All but IHSS 114 have been identified and approved for No Further Action (NFA); therefore, the scope of this IM/IRA is limited to the closure of the Present Landfill. The historical information provided in this section is from the Phase I IM/IRA and Closure Plan (DOE 1996).

2.1 Operational History

The Present Landfill is located in No Name Gulch, at the western limit of headward erosion and pediment dissection. Beginning in 1968, a portion of the natural drainage at the headwaters of No Name Gulch was filled with soils from an onsite borrow area to a thickness of approximately 5 feet to construct a surface on which to begin landfilling operations. The landfill does not have a bottom liner. Wastes delivered to the landfill were spread across the work area, compacted and covered with a daily soil cover, eventually filling the valley to the top of the pediment, at approximately 6,000 feet. Some waste material is confined laterally by the bedrock slopes of the valley and by an existing surface water diversion ditch.

The Present Landfill was placed into service in August 1968 for the disposal of uncontaminated solid wastes, including office trash, paper, rags, personal protective equipment, construction and demolition debris, scrap metal, empty waste containers, used filters, and electrical components. Although originally planned as a sanitary landfill, routine operations at the Present Landfill included disposal of materials containing PCBs, (e.g., used fluorescent light ballast), combustible materials contaminated with small amounts of beryllium particulate matter; and hazardous waste streams such as paints, solvents, and foam polymers. Hazardous wastes were disposed at the landfill until the fall of 1986.

In addition, radioactively contaminated sludge from the Building 995 sanitary waste treatment plant was routinely disposed at the Present Landfill from August 1968 through May 1970. Approximately 2,200 pounds of sludge containing low levels of plutonium and depleted uranium were buried in the landfill.

Beginning in 1985, ACM was disposed in designated 10-foot-deep pits located east of the Present Landfill. The ACM was wrapped in heavy plastic bags, placed in the pit, and covered with soil. Site records indicate that disposal of ACM continued until April 1990.

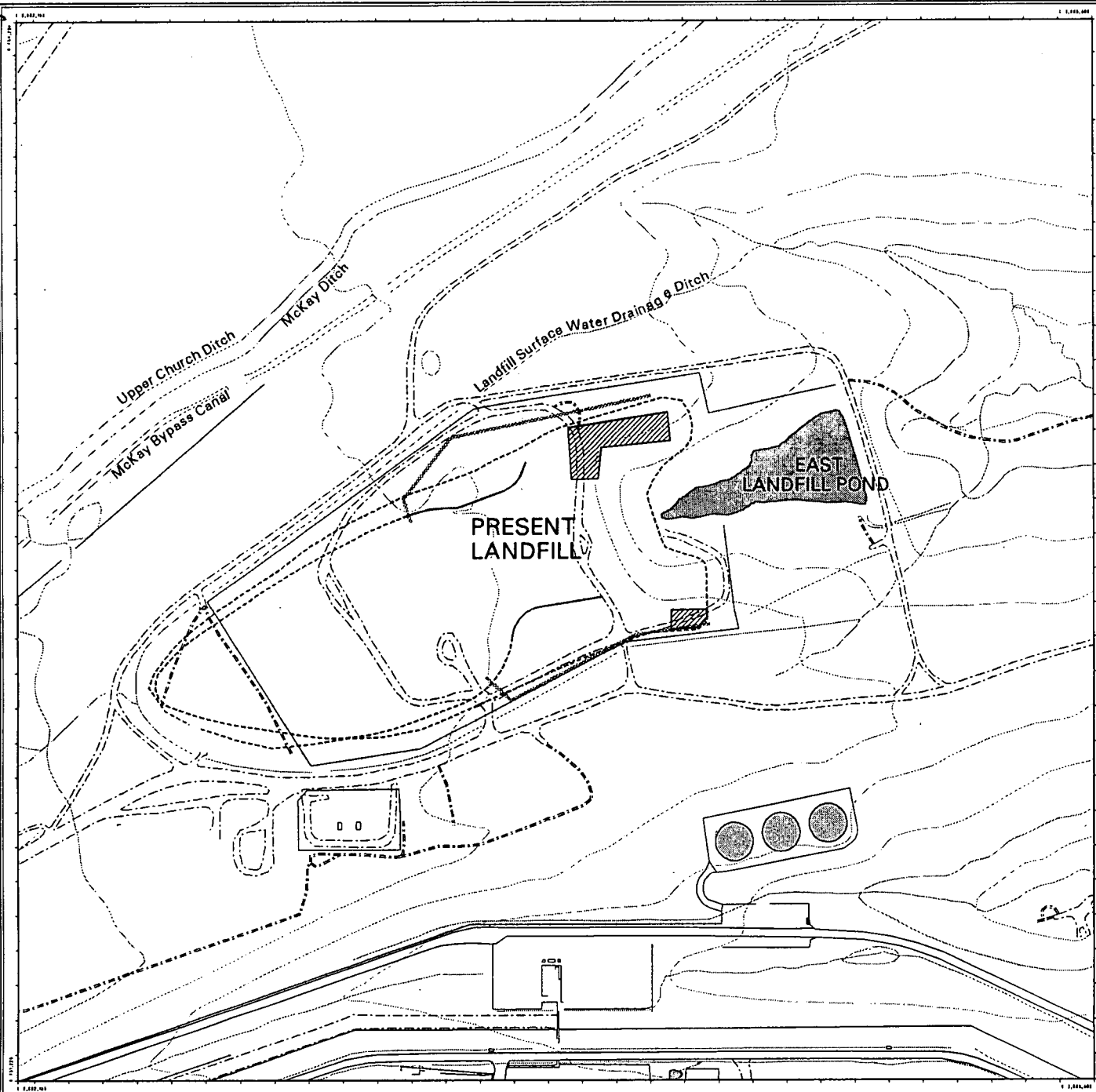
Non-routine wastes disposed in the Present Landfill included tear gas powder, a tank containing Mercaptan™ (an odor additive to natural gas), a drum of solidified polystyrene resin used in fiberglassing operations, soil contaminated with approximately 700 gallons diesel fuel, wood contaminated with chromium, aluminum oxide, unknown chemicals, and unknown reactive chemical residues.

The Present Landfill remained in operation until March 1998, at which time it was placed in a contingent closure status and seeded to stabilize soils and control erosion.

The Present Landfill occupies an area of approximately 20 acres. Waste material is generally thinnest along the boundaries and thickest along the east-west axis of the landfill. Thickness ranges from less than 1 foot to approximately 40 feet near the east face of the landfill.

11

Figure 2
Present Landfill



EXPLANATION

- Slurry Wall
- GW Intercept System - Perforated
- GW Intercept System - Non-Perforated
- Extent of Waste
- Asbestos Disposal Area
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Topographic Contour (20-Foot)
- Paved roads
- Dirt roads



Scale = 1 : 4980
1 inch represents 415 feet



State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:
DynCorp
THE ART OF TECHNOLOGY

Prepared for:
DOE
HOUSEHOLD

OS Dept. 303-966-7767

April 16, 2002

NT_Srv_w:\projects\fy2002\02-0532\present_landfill_fig2.am1

Leachate has been forming at the Present Landfill since waste operations began in 1968. Leachate is a product of natural biodegradation, infiltration of precipitation, and migration of groundwater through the landfill waste. Infiltration at the ground surface and groundwater inflow are the primary sources of water to the landfill. The volume of leachate within the landfill varies as the potentiometric surface fluctuates in response to infiltration and percolation of precipitation through the soil cover. The depth to leachate within the landfill is approximately 20 feet at the western end, 16 feet in the middle, and 33 feet at the eastern end.

2.2 Interim Response Actions

In 1973, tritium and strontium were detected in the leachate draining from the Present Landfill. As a result, approximately 57 monitoring wells were installed directly into the landfill waste and immediately below the waste materials, and a sampling program was initiated to determine the location of the source. The highest measured concentrations were 301,609 picocuries of tritium per liter of leachate and 7 picocuries of strontium. The approximate location of the source was determined to be in an area of the landfill used during 1970, but the source was never identified or removed. By 1980, tritium concentrations had dropped to approximately 500 picocuries per liter.

As a result of the tritium incident, a radiation monitoring program was established to prevent further disposal of radioactive materials and several interim response actions were undertaken to control the generation and migration of landfill leachate. In 1974, a surface water diversion ditch was constructed around the perimeter of the landfill to divert surface water run-off and reduce the infiltration of surface water into the landfill. The diversion ditch is approximately trapezoidal in shape, and is 2 to 3 feet deep and 5 feet wide at the bottom. The slopes and floor of the ditch are composed of sparsely vegetated native soil. On the north side of the landfill, the ditch runs under a perimeter road, through a small culvert, and east into a small, natural drainage that eventually joins No Name Gulch below the East Landfill Pond. On the south side of the landfill, the ditch runs east above the East Landfill Pond and drops into the unnamed tributary to No Name Gulch below the East Landfill Pond dam. No waste disposal is known to have occurred outside the surface water diversion ditch.

As part of the original interim response action, two berms were constructed across the drainage immediately downstream of the landfill, forming two detention ponds. The West Landfill Pond impounded leachate generated by the landfill. The East Landfill Pond provided a backup system for overflow from the West Landfill Pond and was also used to collect intercepted groundwater. Later, a more permanent embankment was constructed for the East Landfill Pond, consisting of an engineered dam with a spillway designed to retain the majority of the water in the channel. To reduce seepage from the pond, a low-permeability clay core was constructed within the embankment, keyed to bedrock. Between 1977 and 1981, the West Landfill Pond was buried as the landfill was expanded. The East Landfill Pond covers approximately 2.5 acres and has a capacity of approximately 7.5 million gallons. Pond water levels are controlled to prevent overflow into the spillway draining to No Name Gulch. Originally, water volume was controlled by periodic spray evaporation to areas located on the north and south banks of the East Landfill Pond (IHSSs 167.2 and 167.3). Spray evaporation operations were discontinued in 1994. Since that time, the pond level has been controlled by pumping the water to Pond A-3 (via the Pond A-1 bypass) for eventual discharge from the Site.

Also in 1974, a two-part subsurface groundwater interceptor system (GWIS) was installed around the perimeter of the Present Landfill, inside the surface water diversion ditch. The system is comprised of a groundwater collection system and leachate collection system. The groundwater collection system was designed to intercept and divert groundwater flow around the landfill, thereby reducing the volume of leachate generated from the landfill waste. The leachate collection system was designed to collect the leachate for discharge to the West Landfill Pond. When the West Landfill Pond was covered in 1981, the

leachate collection system was not re-routed to drain into the East Landfill Pond; therefore, it is presumed the leachate collected by the system still drains to the area of the buried West Landfill Pond. The East Landfill Pond now receives leachate draining from the face of the landfill.

In 1982, two, 900-foot soil-bentonite slurry walls were constructed near the eastern end of the Present Landfill to prevent groundwater migration into the expanded landfill area. The slurry walls were tied into the north and south arms of the groundwater interceptor system.

In 1992, five gas vents were installed in the Present Landfill to release gases generated by microbial degradation of organic waste. The composition, quantity, and generation rates of the gases depend on factors such as waste quantity and composition, waste placement characteristics, landfill thickness, moisture content, and oxygen levels. Carbon dioxide is the principal gas generated during the early stages of waste burial, as the waste undergoes aerobic microbial degradation. As oxygen is depleted, anaerobic microbial degradation produces methane and carbon dioxide.

In 1995, a gravity-flow treatment system was constructed to collect contaminated groundwater and leachate flowing from the eastern end of the Present Landfill. The system was designed to treat the leachate and eliminate F039-listed wastes¹ prior to discharge to the East Landfill Pond. The treatment system was originally composed of a settling basin, bag filters to remove suspended solids, and granular activated carbon (GAC) to remove organic chemical constituents, including volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs).

The effectiveness of the treatment system was evaluated in 1998, at which time it was determined that the primary contaminants detected above the established performance standards are benzene and vinyl chloride. The evaluation also noted that GAC has a very limited capacity to attenuate vinyl chloride, and the system would require costly monthly carbon replacement to maintain its effectiveness. As a result, the system was modified in October 1998 to treat the seep water by passive aeration, and sampling and analysis for SVOCs, metals, and radionuclides was discontinued. The modified system minimizes waste generation and is more effective in removing vinyl chloride. The modified system also results in some treatment of the SVOCs, although it is primarily designed to treat VOCs.

In the modified passive aeration treatment system, the water is collected in a settling basin, then it flows through a pipe, to a set of stepped flagstones, and over a 6-foot long bed of gravel, before discharging into the East Landfill Pond. Flow is measured at the point of discharge. Water quality samples are collected from the treatment system discharge endpoint, defined as the point 6 feet downstream from the last aeration step. Water released from the treatment system is collected in the East Landfill Pond, which is periodically pumped to Pond A-3.

2.3 Geologic Setting

The geology at the Present Landfill is a function of the regional tectonic setting and local depositional and erosional conditions. Geologic data used to characterize the Present Landfill were compiled from previous landfill investigations; existing geologic characterization reports; U.S. Geological Survey publications; Colorado School of Mines reports; the Phase I RFI/RI; and the supplemental Phase I field investigation. A summary of the general geologic framework, description and distribution of surficial and bedrock geologic units, description of geotechnical properties, and description of pond sediments are presented in the following paragraphs. Geologic borehole logs are contained in the OU 7 Final Work Plan (DOE 1994).

¹ F039 is defined as "leachate (i.e., liquids that have percolated through land disposed wastes) resulting from the disposal of more than one restricted waste classified as hazardous under Subpart D of 6 CCR 1007-3, Part 261.31."

2.3.1 General Geologic Framework

RFETS is situated on an eastward-sloping plain, immediately east of the Colorado Front Range. The surface cover is composed of a series of coalescing alluvial fans that developed during the Pleistocene epoch. The Present Landfill is located near the eastern extent of the alluvial fans, which were deposited on a broad, gently-sloping erosional surface, or pediment, underlain by more than 10,000 feet of gently dipping (i.e., less than 2 degrees) sedimentary rocks deposited between the Pennsylvanian and Upper Cretaceous periods.

Dissection of the gravel-capped pediment has occurred by headward erosion and planation along eastward-flowing streams and their tributaries. Fluvial processes have formed moderately steep hillsides adjacent to the stream drainages, with the steepest slopes formed along the tops of the incised drainages. Surficial and bedrock geologic units that influence groundwater flow include the artificial fill material of the landfill, the Rocky Flats Alluvium, and the underlying Arapahoe and Laramie Formations. The Fox Hills Sandstone occurs at a depth of approximately 700 to 800 feet below the ground surface, which is too deep to be affected by the landfill.

2.3.2 Description of Geologic Units

Surficial material at the Present Landfill consists of quaternary-aged alluvial fan deposits of the Rocky Flats Alluvium, colluvial deposits, alluvial deposits of the valley-fill alluvium, and artificial fill. All surficial deposits are part of the upper hydrostratigraphic unit (UHSU).

The Rocky Flats Alluvium caps the divides north and south of No Name Gulch. It is 25 to 30 feet thick on the northwest, west, and southwest sides of the landfill, and 10 to 15 feet thick on the divides north and south of the East Landfill Pond. The Rocky Flats Alluvium is composed of reddish-brown to yellowish-brown, well-graded, coarse gravel in a clayey-sand matrix. Pebbles and cobbles are composed of quartzite, granite, and gneiss. Maximum clast size recovered during drilling ranges from 1 to 3 inches in diameter. Caliche, a porous calcium carbonate cement, was described in drill cores from the divides north and south of the East Landfill Pond. These zones may be discharge points for alluvial groundwater along the hillsides above the pond.

Colluvial materials have been deposited by slope wash and downward creep of alluvial material and bedrock. Colluvium covers the hillsides between the pediment on which the Rocky Flats Alluvium is deposited and the No Name Gulch drainage and East Landfill Pond. It is 1 to 5 feet thick on the slopes around the pond and below the dam, and consists of brown, structureless clay with some sand and a trace of gravel. Soil development has occurred and roots are present to a depth of 3 feet.

Valley-fill alluvium, derived from reworked alluvial material and bedrock, is present in the No Name Gulch drainage below the East Landfill Pond. The alluvium is 3 to 8 feet thick in the area of the Present Landfill and becomes thicker downstream to the east. The alluvium consists of brown, laminated to structureless clay with lenses of gravel. Gravels have a sandy-silt matrix that is often stained with iron.

Artificial fill and disturbed surficial materials are present within the boundaries of the Present Landfill. Thickness of the fill, which includes waste and interim soil cover, ranges from approximately 5 to 45 feet. Fill is thickest near the centerline of the valley and thinnest around the perimeter of the landfill, inside the surface water diversion ditch. An actively slumping area occurs in the artificial fill material on the northeast side of the landfill. Seeps are observed along the slope in this area.

Bedrock, consisting of claystones, siltstones, and fine-grained sandstones of the undifferentiated Upper Cretaceous Arapahoe and Laramie Formations, unconformably underlies the surficial deposits. In general, the base of the Arapahoe Formation, which unconformably overlies the Laramie Formation, is

marked by the presence of medium-grained to conglomeratic sandstones composed of well-rounded, frosted, quartz sand grains with pebbles of chert, rock fragments, and ironstone. The lowermost 20 feet of the Arapahoe Formation are shown underlying the Rocky Flats Alluvium on the divides north and south of No Name Gulch on geologic maps of Rocky Flats. However, sandstones exhibiting the distinctive characteristics of the basal Arapahoe Formation or No. 1 sandstone are not exposed at the surface or in any of the drill cores from the Present Landfill. The contact between the Arapahoe and Laramie Formations is difficult to interpret in the absence of the marker (i.e., No. 1) sandstone bed. Therefore, in this document, the Arapahoe and Laramie formations are undifferentiated. However, in the No Name Gulch drainage downgradient of the landfill, the elevation of the bedrock is low enough that it is likely the Laramie Formation.

The Laramie Formation is composed of laterally extensive sandstones, kaolinitic claystones, and coal beds, and is approximately 600 to 800 feet thick. The upper 300 to 500 feet consist primarily of olive-gray and yellowish-orange claystones. Four sandstone units (designated as Nos. 2, 3, 4, and 5 sandstones) have been identified as the bedrock beneath the No. 1 sandstone and are considered to be Upper Laramie Formation. Where present, the sandstones are olive-gray, very fine-grained, subangular, well-sorted, locally calcareous, silty, and clayey. Because they lie within claystones and are not in hydraulic connection with either the No. 1 sandstone or the surficial deposits, the No. 2 through No. 5 sandstones are not considered significant pathways for migration of contaminants.

The bedrock at the Present Landfill is composed of gray to brown, structureless claystones containing a trace of carbonaceous material and occasional thin interbeds of siltstone and, less frequently, fine-grained sandstone. Sandstones are composed of gray, very fine to fine-grained, subangular to sub-rounded, well-sorted, quartzose sand. Sandstones are frequently interbedded with siltstones. These coarse-grained units vary from 1 to 30 feet thick.

2.3.3 Distribution of Geologic Units

Geologic units beneath the Present Landfill consist of a thin covering of colluvium on the hillsides and valley-fill alluvium in the No Name Gulch drainage. Both are underlain by the Laramie Formation. The colluvium consists of clays and silts. The valley-fill alluvium is composed of gravelly, clayey sand. Geologic units on the groundwater divides adjacent to the landfill consist of Rocky Flats Alluvium, underlain by the undifferentiated Arapahoe and Laramie Formations. The Rocky Flats Alluvium consists of clayey gravels and sands. Lithologies of the undifferentiated Arapahoe and Laramie Formations are typically limited to claystones and siltstones.

Fine-grained sandstone subcrops beneath the alluvium, downgradient of the East Landfill Pond dam. This sandstone pinches out approximately 500 feet down stream. Shallow sandstones, present within 15 feet of the contact between the alluvium and bedrock, were encountered in wells located within the landfill on the south side and on the southwest shore of the East Landfill Pond. Based on a 2-degree regional dip, it is expected these shallow sandstones do not subcrop in the area of the Present Landfill and are not preferential pathways for migration of contaminants.

Other Laramie Formation sandstones are present at depths where there is no hydraulic connection with surficial deposits. Laramie Formation sandstones, sometimes referred to as the No. 2 through No. 5 sandstones, were identified near the East Landfill Pond, within the landfill, and downgradient of the dam, in No Name Gulch. Laramie Formation sandstones were also identified at depths of 50 to 125 feet below ground surface.

18

2.3.4 Landfill Pond Sediments

Sediments have been accumulating in the East Landfill Pond since its construction in 1974. The sources of contaminant loading to the pond sediments include the leachate seep and surface water run-off from surrounding slopes. Results from sampling events performed during the Phase I RFI/RI indicate the sediments consist of clay, silt, and organic matter, ranging from 0.5 to 0.8 feet thick. The upper 0.2 to 0.5 feet of sediments consist of black silt and clay, with very fine roots occurring in either thin mats or scattered throughout the core. No bedding or lamination was visible. The remaining 0.3 to 0.4 feet of core consisted of very dark gray clay with some silt. Very fine roots were observed, decreasing with depth. The pond sediments are underlain by olive-gray claystone of the Laramie Formation.

2.4 Hydrogeologic Setting

The hydrology at the Present Landfill is a function of the general geologic framework, recharge and discharge conditions, physical properties of the aquifer materials, hydrodynamic conditions, and landfill structures. Hydrogeologic data used to characterize the landfill were compiled from previous landfill investigations; sitewide groundwater monitoring, assessment, and protection plans and reports; and water-level measurement and hydraulic conductivity test activities conducted as part of the Phase I RFI/RI and supplemental field investigations. Drawdown-recovery test data and analytical solutions from the supplemental Phase I field investigation and additional information on the hydrogeology at the Present Landfill is presented in the OU 7 Final Work Plan (DOE 1994).

2.4.1 Uppermost Aquifer

The "uppermost aquifer" is equivalent to the UHSU, as described in RFETS reports. In the area of the Present Landfill, the UHSU is composed of unconsolidated surficial deposits and weathered bedrock. The unconsolidated deposits consist of Rocky Flats Alluvium, colluvium, and valley-fill alluvium. The Rocky Flats Alluvium and artificial fill (i.e., landfilled wastes and soil-cover materials) are present upgradient of and within the landfill; colluvium and valley-fill alluvium are present downgradient of the landfill. Weathered claystones and weathered sandstones that are in direct hydraulic communication with the overlying surficial deposits, are also considered part of the "uppermost aquifer." The weathered claystones are generally more permeable than unweathered bedrock. Unweathered claystones are not considered to be part of the uppermost aquifer but are included as part of the lower hydrostratigraphic unit (LHSU). Bedrock wells were assigned to a hydrostratigraphic unit based on geochemical data from the well, hydraulic conductivity measurements (where available), and information from borehole logs. The Rocky Flats Alluvium is 25 to 30 feet thick on the northwest, west, and southwest sides of the landfill, and 10 to 15 feet thick on the divides north and south of the East Landfill Pond. Colluvium is 1 to 5 feet thick on the slopes around the pond and below the dam. The valley-fill alluvium ranges in thickness from 3 to 8 feet in the landfill area and becomes thicker downstream to the east. The thickness of artificial fill increases from about 5 feet at the perimeter of the landfill to about 45 feet near the centerline of the valley. Weathered bedrock material thicknesses vary considerably in the vicinity of the landfill, ranging from approximately 4 to 35 feet.

Average depth to groundwater ranges from 5 to 15 feet in surficial deposits, excluding artificial fill. Within the Present Landfill, groundwater is found at approximately 20 feet at the western end, 16 feet in the middle, and 33 feet at the eastern end. The depth to groundwater in weathered bedrock is generally greater than that of the overlying surficial deposits due to steep downward vertical gradients in bedrock materials. Saturated thickness of UHSU deposits vary widely across the landfill, with the thickest sections found in the Rocky Flats Alluvium at the western end, and thinnest sections found in colluvial and valley-fill deposits east of the East Landfill Pond and in the Rocky Flats Alluvium along the south divide.

Geologic units beneath the landfill waste consist of a thin covering of colluvium on valley slopes and valley-fill alluvium in the No Name Gulch drainage, both underlain by the Laramie Formation. Lithologies of the colluvium are clays and silts. Lithology of the valley-fill alluvium is gravely, clayey sand. Lithologies of the Laramie Formation typically include claystone and siltstone.

The mean hydraulic conductivity values for the landfill waste, colluvium, and valley-fill alluvium range from 1×10^{-4} centimeters per second (cm/sec) to 1×10^{-5} cm/sec. The mean hydraulic conductivity value for the underlying weathered bedrock of the Laramie Formation ranges from 1×10^{-6} to 1×10^{-7} cm/sec.

2.4.2 Potentiometric Surface

Groundwater is present in surficial deposits and artificial fill, and in bedrock sandstones and claystones in the area of the Present Landfill. Within the landfill wastes, groundwater flows toward the center of the landfill, then eastward toward the East Landfill Pond. Outside the landfill, groundwater generally flows eastward within saturated UHSU surficial deposits, except near stream valleys, which disrupt UHSU flow patterns and function as drains for UHSU groundwater. For example, near the East Landfill Pond, groundwater flows from the north, west, and south toward the pond because of its topographically low position in the No Name Gulch drainage. Groundwater entering the East Landfill Pond mixes with surface water and evaporates, is pumped to Pond A-3, or, to a limited extent, percolates downward into underlying bedrock materials or laterally through the dam. Groundwater seepage past the dam, into the lower drainage, flows eastward along the stream course until it is discharged via evapotranspiration, surface water, or as lateral subsurface flow at the Indiana Street east boundary.

Groundwater elevations in monitoring wells are measured at least quarterly. Water levels in the surficial deposits of the UHSU are characterized by seasonal variations of as much as 10 feet. The elevation of the water table is generally lowest in late winter and early spring, prior to recharge by snowmelt, and highest during June and July. Groundwater elevations in the weathered bedrock of the UHSU typically show seasonal variations of as much as 15 feet.

The alluvium and weathered bedrock are frequently dry or thinly saturated because the dam acts as a barrier to alluvial groundwater flow from the west. In addition, evapotranspiration demands of valley-bottom vegetation consume much of the available shallow groundwater in the gulch during the summer months. For these reasons, it is normally not possible to collect complete sample sets for each quarterly sampling period during the year.

Many of the wells in the vicinity of the Present Landfill have been abandoned and are no longer in service. The limited number and position of the remaining wells make it infeasible to construct potentiometric surface maps and concentration isopleth maps.

2.4.3 Vertical Hydraulic Gradients

The vertical hydraulic gradient is the quotient of the differences in water levels measured concurrently in two adjacent wells with different screened intervals, and the vertical distance between the two measuring points, which are specified here as the midpoint of each screened interval. Vertical hydraulic gradient calculations provide a means to evaluate whether groundwater flow has a potential for movement either downward or upward through geologic media.

Most well pairs at the Present Landfill have been abandoned or deactivated in recent years in preparation for landfill closure. Consequently, current water level data are unavailable for calculation of vertical gradients. The results of historical vertical hydraulic gradient calculations at 8 landfill monitoring well pairs (70093/70193, 70193/70293, 70493/70593, 70693/70893, 72393/72093, 1086/0986, 0786/0886, and B206989/B207089) monitored through 1995 provide information relevant to understanding groundwater

conditions at the landfill (see Figure 3). The calculated vertical hydraulic gradients for all well pairs, except 72393/72093, indicate a downward (recharging) component of flow, with values ranging from 0.022 to 1.099 ft/ft. The significance of downward gradients at well pairs 0786/0886 and B206989/B207089, located near the bottom of No Name Gulch, are, however, potentially invalid considering the water levels in the bedrock wells at these locations recharge slowly and never fully recover between sampling episodes. At well pair 72393/72093, situated within the center of the landfill, groundwater has an upward (discharging) vertical gradient ranging from 0.020 to 0.026 ft/ft. Data from the well pairs indicate that vertical hydraulic gradients have generally remained constant over time. This condition may exist because disturbances to the landfill hydrologic system have been minimal in recent years. In addition, groundwater flow within the deeper portions of the UHSU and LHSU bedrock is relatively insensitive to fluctuations in seasonal water levels and other short-term transient effects because of the prevalent low permeability of bedrock materials.

2.4.4 Groundwater Flow Velocities

The average linear groundwater-flow velocity has historically been calculated for three flow-paths in UHSU surficial deposits and three flow-paths in UHSU bedrock in the vicinity of the Present Landfill. Most of the well pairs were deactivated in 1995 in preparation for landfill closure. However, the variables used in calculating flow velocities (hydraulic conductivity, porosity, and hydraulic gradient) have remained effectively constant over time. Therefore, the following discussion is considered indicative of current conditions in the Present Landfill.

Migration rates for conservative, dissolved constituents approximate the average linear groundwater-flow velocity; however, attenuated, volatile, biodegradable, or redox-sensitive species can exhibit migration rates much less than the average linear groundwater-flow velocity. The values of hydraulic conductivity used for surficial deposits and bedrock of the UHSU are the geometric means of hydraulic-conductivity values for each unit at the Present Landfill, and include results of historic slug tests. Values of hydraulic conductivity used for flow velocity calculations are 1.1×10^{-4} cm/sec for surficial deposits (including landfill wastes) and 5.3×10^{-7} cm/sec for UHSU bedrock materials. The assumed effective porosity for all units is 0.1. Using these data, the calculated average linear groundwater-flow velocities in fill materials range from approximately 1 foot per year at the west end of the Present Landfill to approximately 160 feet per year at the advancing eastern face of the landfill. Calculated average linear groundwater-flow velocities in UHSU bedrock at the landfill range from approximately 0.20 feet to 0.22 feet per year beneath the landfill, to approximately 0.07 feet to 0.41 feet per year downgradient of the landfill.

2.5 Conceptual Flow Model

The conceptual flow model for the Present Landfill includes surface water hydrology, interactions between surface water and groundwater, and groundwater hydrology:

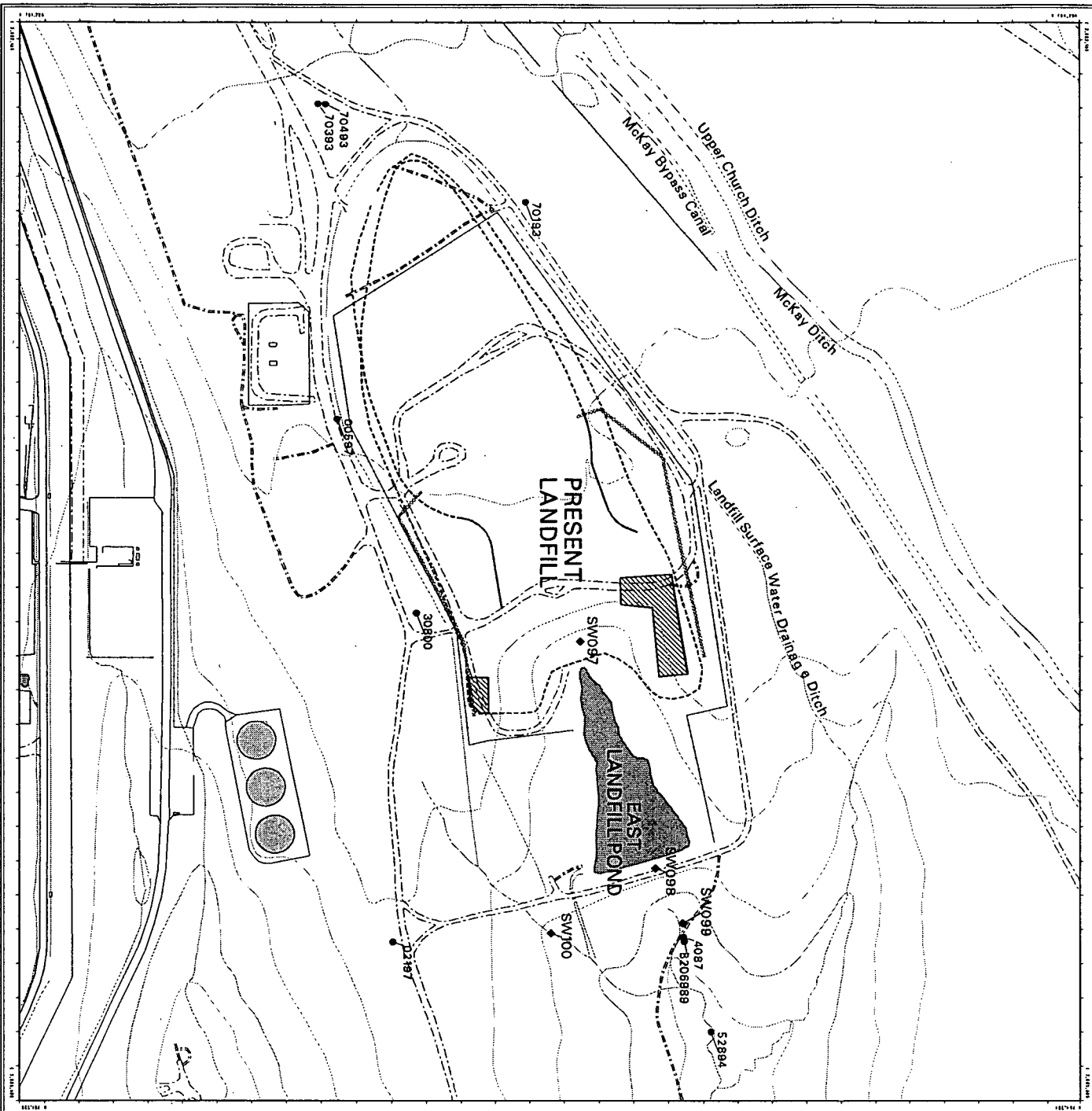
- Surface water hydrology components of the conceptual model include precipitation, evapotranspiration, pond evaporation, surface water run-off, and engineered water transfers.
- Interactions between surface water flow and groundwater flow include infiltration and percolation, interflow, historical seep flow at SW097, groundwater baseflow into the East Landfill Pond, discharge from the existing groundwater-intercept system into the pond, and seepage flow downward out of the pond.
- Groundwater hydrology components include groundwater flow in surficial materials, seepage between surficial materials and weathered bedrock, groundwater flow in weathered bedrock, seepage between weathered bedrock and unweathered bedrock, and groundwater flow in unweathered bedrock.

21

ec

Figure 3
Present Landfill Wells

- EXPLANATION**
- Groundwater Monitoring Well
 - ◆ Surface Water Monitoring Locations
 - Slurry Wall
 - GW Intercept System - Perforated
 - GW Intercept System - Non-Perforated
 - Extent of Waste
 - ▨ Asbestos Disposal Area
 - ▧ Lakes and ponds
 - Streams, ditches, or other drainage features
 - Fences and other barriers
 - Topographic Contour (20-foot)
 - Paved roads
 - Dirt roads



U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:
DynCorp
3000 West 10th Avenue
Boulder, CO 80502

Prepared for:
DOE
300 West 10th Avenue
Boulder, CO 80502

April 28, 2002

Recharge, discharge, and interactions between the surface water and groundwater components of the conceptual model are presented briefly here and discussed in more detail in the following subsections.

Recharge or infiltration and percolation is a significant source of water to the landfill mass. Groundwater inflow under or through the existing groundwater interceptor system is another significant source of water to the landfill. These two sources of inflow are quantified in a water balance performed using numerical modeling. Outflow from the landfill mass is funneled to the vicinity of the seep at SW097, where it exits the landfill as either seep flow or groundwater baseflow. The East Landfill Pond collects surface water run-off, seep flow, and groundwater baseflow. The dam acts as a barrier to the flow of groundwater in surficial materials. Flow in weathered bedrock is much less than flow in surficial materials. Some preferential flow paths, most likely fractures, exist in the weathered bedrock. These preferential flow paths are potential contributors to the migration of contaminants in weathered bedrock. Flow in unweathered bedrock is so small that any potential contaminant transport occurs by diffusion.

2.5.1 Surface Water Hydrology

Surface water features resulting from historical interim response actions control surface water hydrology. A surface water diversion ditch was constructed around the perimeter of the Present Landfill in 1974 to divert surface water run-off around the landfill and reduce infiltration of surface water into the landfill, thereby reducing the volume of leachate discharging as seep flow. On the north side of the landfill, the ditch runs under a perimeter road through a small culvert and east into a small, natural drainage that eventually joins No Name Gulch below the East Landfill Pond dam. On the south side of the landfill, the ditch runs east above the East Landfill Pond and drops into No Name Gulch below the dam. The diversion ditch is 2 to 3 feet deep, 5 feet wide at the bottom, and has a trapezoidal shape. The slopes and floor of the ditch are composed of sparsely vegetated native-soil material.

The East Landfill Pond covers approximately 2.5 acres. Pond water levels are controlled to prevent overflow into the spillway draining to No Name Gulch. Recharge to the pond occurs from groundwater baseflow in surficial materials, leachate from the seep, and surface water run-off from the landfill and surrounding slopes. Discharge occurs by natural evaporation, seepage downward into weathered bedrock, seepage through the clay core of the dam, and annual water transfers to the A-Series ponds.

Surface water hydrology components include precipitation, evapotranspiration, pond evaporation, surface water run-off, and water transfers from the East Landfill Pond to the A-Series ponds. Mean annual precipitation at RFETS, including rainfall and snowmelt, is nearly 16 inches. Approximately 40 percent of the annual precipitation falls during April, May, and June. An additional 30 percent falls in July and August. Approximately 19 percent falls during September, October, and November. The remaining 11 percent falls in December, January, February, and March.

Pond evaporation is estimated at 70 percent of the pan evaporation, which ranges from 1 inch in December and January to 7 inches in September. Potential evapotranspiration varies in a pattern similar to that shown by pan evaporation. Site-specific potential evapotranspiration data are not available. At any given time, precipitation in excess of evapotranspiration will become surface water run-off, infiltration, or interflow.

Surface water run-off from the landfill and from the area surrounding the pond is a major contributor to pond water. Some portion of the run-off is diverted by the surface water diversion ditch, while a significant fraction flows to the East Landfill Pond. Water is periodically transferred to the A-Series ponds to control the water level in the East Landfill Pond.

2.5.2 Interactions Between Surface Water & Groundwater

Interactions between surface water and groundwater include infiltration and percolation, interflow, historical seep flow at SW097, groundwater baseflow into the East Landfill Pond, discharge from the existing groundwater-intercept system into the pond, and seepage flow downward, out of the pond.

Infiltration is the process by which precipitation moves downward into the soil and includes flow within the unsaturated zone. For purposes of the conceptual model, water that infiltrates reaches the groundwater table and recharges the groundwater in surficial materials. Infiltration at the Present Landfill is assumed to be between 5 and 10 percent of the mean annual precipitation (i.e., 0.8 to 1.6 inches).

Interflow is subsurface flow in the horizontal direction above the water table. It is usually associated with storm events on hillsides. Interflow may be a significant contributor to the variability of the flow at the seep (SW097).

Leachate discharges from the seep located at the base of the east face of the Present Landfill. Seep flow varies throughout the year and has been estimated at 1 to 7 gallons per minute (gpm). A significant fraction of the groundwater flow from the landfill is funneled toward the seep. The seep originated from the original stream channel in No Name Gulch, which was filled in during construction and subsequent waste disposal in the landfill. The seep is also directly downgradient of the former West Landfill Pond dam, which was breached before being covered with waste and interim soil cover. This breached dam may serve to further direct groundwater flow toward the seep area. As stated above, interflow is potentially a major source of the variability of the historical seep flow.

An intermittent seep has been observed north of SW097 on the hillside just below the north asbestos disposal area. This intermittent seep is most likely caused by saturated materials related to storm events. Heavy surface water run-off has been observed in this area following storm events. Recent slumps have also been observed.

Groundwater baseflow exists in surficial materials and weathered bedrock. In surficial materials, the baseflow that does not intersect the ground surface at the seep is a source of recharge to the East Landfill Pond. The saturated thickness of the surficial materials at the edge of the East Landfill Pond is much less than the saturated thickness directly to the west in the landfill. This reduction in saturated thickness contributes to the formation of the seep. Evidence of preferential flow also exists. The seep historically flows year-round while nearby alluvial well 0786 is often dry. In weathered bedrock, the potentiometric surface is below the bottom of the pond and the baseflow in the weathered bedrock is not expected to be a source of recharge to the pond.

Water seeps from the East Landfill Pond, into the weathered bedrock, and through the weathered bedrock under the dam. Some water also seeps through the dam core. Flows are expected to be small, based on the measured hydraulic conductivities in the weathered bedrock and the dam core. This seepage is not effective in recharging the weathered bedrock downgradient of the pond. The weathered bedrock wells B206889 and B206989 directly below the dam consistently exhibit water levels 12 to 15 feet below the top of bedrock, indicating only partial saturation of weathered bedrock and a "perched" water table condition for surficial materials.

The East Landfill Pond dam impedes groundwater flow in surficial materials and the wells in surficial materials directly downgradient of the dam are often dry. The alluvium and weathered bedrock at these locations are frequently dry or thinly saturated because the dam acts as a barrier to alluvial groundwater flow from the west. In addition, evapotranspiration demands of valley-bottom vegetation consume much of the available shallow groundwater in the gulch during the summer months.

Less information on surface water hydrology, interactions between surface water and groundwater, and groundwater hydrology is available for the No Name Gulch drainage downgradient of the landfill than for the landfill area itself. It appears that No Name Gulch is a losing stream year-round. There are four surface water stations downgradient of the landfill. Two of the stations measure flow from the landfill surface water diversion ditch. These ditches convey storm water run-off around the north and south sides of the landfill. A third station is located at the confluence where the ditches discharge into No Name Gulch. Limited flow information is available for these stations.

Based on a detailed study of groundwater and surface water interactions in Woman Creek, the only reaches of the stream where groundwater recharges surface water either year-round or seasonally are located in the western portion of the BZ, adjacent to large gravel-capped pediments containing substantial subsurface flows. A few isolated gaining reaches are fed by localized seeps. No Name Gulch is located adjacent to the distal ends of the gravel-capped pediment surfaces. Gravels are fairly thin in this area and do not contain substantial subsurface flows. In addition, no groundwater seeps have been observed to flow into No Name Gulch below the East Landfill Pond.

2.5.3 Groundwater Hydrology

Groundwater is present in surficial deposits, artificial fill, and bedrock sandstones and claystones in and around the Present Landfill. Groundwater flow patterns tend to mimic the surface topography. Within the landfill wastes, groundwater flows toward the center of the landfill, then eastward toward the East Landfill Pond. Outside the landfill, groundwater generally flows eastward within saturated surficial deposits. Sources of groundwater recharge include infiltration/percolation of precipitation, snowmelt, storm water run-off, and downward seepage from the East Landfill Pond. Discharge occurs through evapotranspiration and surface seepage where the water table intersects the ground surface.

Groundwater levels rise annually in response to spring and summer recharge, and decline during the remainder of the year. Water levels in the surficial deposits are characterized by seasonal variations of as much as 10 feet. Groundwater elevations in the weathered bedrock typically show seasonal variations of as much as 15 feet. The alluvium and weathered bedrock at these locations are frequently dry or thinly saturated because the East Landfill Pond dam acts as a barrier to alluvial groundwater flow from the west. In addition, valley-bottom vegetation consumes much of the available shallow groundwater during the summer months.

Average depth to groundwater ranges from 5 to 15 feet in surficial deposits. Within the landfill, groundwater is found at approximately 20 feet at the western end, 16 feet in the middle, and 33 feet at the eastern end. The depth to groundwater is anomalously high in the middle of the landfill because groundwater is flowing into this area from the north side of the landfill. The depth to groundwater in weathered bedrock is generally greater than that of the overlying surficial deposits due to steep downward vertical gradients in bedrock materials. Flow in weathered bedrock is much less than flow in surficial materials. Some preferential flow paths, most likely fractures, exist in the weathered bedrock. These preferential flow paths are potential contributors to the migration of contaminants in the weathered bedrock.

Leachate has historically discharged from the seep located at the base of the east face of the Present Landfill. A significant fraction of the groundwater flow from the landfill is funneled toward the seep, while the remainder enters the East Landfill Pond as groundwater baseflow. The seep originated from the original stream channel that was filled during construction of the landfill, and from subsequent waste disposal in the landfill. The seep is also directly downgradient of the location of the former West Landfill Pond dam, which was breached before being covered with waste and an interim soil cover in 1981. This breached dam may serve to further direct groundwater flow toward the seep area. Seep flow varies throughout the year, discharging up to 11 gpm or 5,766,000 gallons per year. Based on seep flow

measurements taken between 1998 and 2001, the 4-year average flow was 2.6 gpm, the average flow during the wettest year (1998) was 3.2 gpm, and the average flow rate during the wettest month of the period (i.e., June 1999) was 3.7 gpm. Although the best records exist for the last 4 years, this period does not represent long-term flow rates because higher flows were reported during the late 1980s and early 1990s. The year 1995 was the wettest year in recent history; however, there are no flow records available for that year.

Between 1973 and 1995 several engineered structures were installed to control the generation and migration of landfill leachate, with varying degrees of success. The current groundwater control system consists of a GWIS installed around the perimeter of the Present Landfill, with a subsurface leachate collection trench and two soil-bentonite slurry walls installed on the northeast and southeast ends of the landfill (Figure 2).

The presence of a groundwater divide between the No Name Gulch and the North Walnut Creek drainages limits the amount of available groundwater flow on the south side of the landfill and contributes to the effectiveness of the groundwater control structures. Also, the saturated thickness of surficial materials is less on the south side of the landfill than on the north side. Groundwater modeling studies have concluded that contributions to groundwater recharge within the landfill are about evenly split between infiltration through the existing soil cover (50 percent) and groundwater inflow through the groundwater control systems (50 percent). Most of the groundwater inflow (90 percent or greater) occurs on the north side of the landfill. Results of modeling studies indicate that approximately 50 percent of the groundwater inflow enters on the north side of the leachate collection trench and approximately 50 percent enters along the north slurry wall. Contributions from the west side (1-10 percent) and the south side (0-7 percent) are relatively insignificant. Estimated groundwater recharge to the Present Landfill ranges from 56,000 cubic feet per year to more than 1,000,000 cubic feet per year.

2.6 Meteorology & Air Quality

RFETS is located in the southern Rocky Mountains and has a continental, semi-arid climate. The region is noted for large seasonal temperature variations, occasional dramatic short-term temperature changes, and strong, gusty winds that reach 75 miles per hour (mph) annually and 100 mph every three to four years. Mean annual precipitation is about 15.5 inches, with about one half of that amount occurring as snow.

Although air quality is generally better at RFETS than in the urbanized portion of the Denver Metropolitan Area, the Site is continuously and extensively monitored for air pollutants. The Site is located within the Metropolitan Denver Intrastate Air Quality Control Region No. 36 (Region). The Region is designated as "nonattainment" with respect to the National Ambient Air Quality Standards for PM₁₀. The particulate matter standard is exceeded within the Region primarily because of fugitive dust.

Radiological air emissions both onsite and offsite are largely unrelated to Site operations. Most radiation is naturally-occurring background radiation from sources such as radon. The annual background dose for Denver area residents is about 418 millirem (mrem). Radioactive emissions from the Site are principally from contaminated soil, with an annual dose for the nearest most impacted offsite resident of about 0.1 mrem. Facilities with potential radionuclide emissions are continuously monitored at emission points to ensure emissions are properly controlled and comply with applicable regulations.

Additional details concerning meteorology, air quality, monitoring, and air emission controls at the Site can be found in the Rocky Flats Cumulative Impacts Document (CID), (DOE, 1997), and the 2000 CID Update Report (DOE 2001a).

26

2.7 Ecological Resources

RFETS supports a diverse association of native grasses, forbs (wildflowers), subshrubs (low shrubs), and cacti typical of prairie environments in the region. Wildlife at the Site is generally characteristic of prairie habitats. A variety of mammals (e.g., mule deer, white-tailed deer, rabbit, coyote, raccoon, beaver, mice), reptiles (e.g., bullsnake, garter snake, prairie rattlesnake, eastern fence lizard), and amphibians (e.g., chorus frog, tiger salamander) are found at the Site. Over 160 species of birds, including waterfowl (e.g., ducks, geese, and shorebirds) and raptors (e.g., red-tailed hawks, great horned owls) have been identified at RFETS. Typical wildlife found in the vicinity of the Present Landfill are species that frequent or intermittently use grasslands (e.g., meadowlarks) and those common in industrial/disturbed settings (e.g., sparrows and starlings). Due to their intermittent nature, North and South Walnut Creeks do not support sizable amounts of aquatic species. Minnow species have been observed in small impoundments in Walnut Creek. No threatened or endangered plant species have been found in the vicinity of the Present Landfill.

A total of 3.1 acres of jurisdictional wetlands are located in the immediate vicinity of the Present Landfill, including 0.8 acres of palustrine emergent wetlands at the margins of the East Landfill Pond, and 2.3 acres of lacustrine wetlands associated with the pond bottom and open-water habitat combined. The 0.8 acres of palustrine wetlands represents about 0.5 percent of the palustrine and riverine wetlands at RFETS. The East Landfill Pond represents about 5 percent of the Site's open water habitat, and about 6 percent of the shoreline habitat.

2.8 Surrounding Land Use & Population

The Site is bordered by State Highway 128 to the north, Indiana Street to the east, State Highway 72 to the south, and State Highway 93 to the west. Land directly north of Highway 128 is largely dedicated to open space. Land east of Indiana Street is zoned industrial/commercial to the north and open space to the south. The City of Broomfield owns the open space to the south of the Site, which includes Great Western Reservoir. The remaining land bordering the Site on the east is zoned agricultural, with a projected plan showing an open space designation. Previous Jefferson County open space east of RFETS is now owned by the City of Westminster. To the south of the Site, privately owned land is used for grazing and hay production, and is zoned agricultural/commercial. To the west, the Site is bordered by private land between the west boundary and State Highway 93. The land to the west is used for quarrying and industrial development. The land southwest of RFETS is owned by the State of Colorado, and is permitted for grazing and mining.

2.9 Nature and Extent of Contamination

Limited characterization of landfill gas and leachate was performed during the Phase I RFI/RI (DOE 1991). Sampling efforts for the Phase I RFI/RI and supplemental Phase I field investigation were focused on characterizing areas where contaminant migration was suspected, such as surface water and sediments in the East Landfill Pond and subsurface geologic materials and groundwater downgradient of the landfill.

A landfill gas study was also performed in 2001 to support the development of the conceptual design for the engineered cover. The nature and extent of contamination in these media are presented below.

In addition, surface water and groundwater monitoring has been (and continues to be) conducted around the Present Landfill in accordance with the Site Integrated Monitoring Plan (IMP). Results are distributed to the regulators and other stakeholders during quarterly data exchanges and published in annual reports.

Site-to-background comparisons have been performed for metals, radionuclides, and indicator parameters using statistical tests. Results were presented in the OU 7 Final Work Plan (DOE 1994) for all media using 1990–1994 data.

Data from the sitewide Background Geochemical Characterization Report (EG&G 1992) were used for background samples of sediment, groundwater, seep water, and surface water. Data from soil samples collected in the Rock Creek drainage were used for background samples of surface soils. Metals, radionuclides, and indicator parameters having elevated concentrations relative to background, as indicated by any one of the inferential statistical tests or the hot-measurement test, were identified as potential contaminants of concern (PCOCs). Organic compounds were considered PCOCs if detected in samples from the Present Landfill.

The data were aggregated into populations that reflect potential collection or treatment alternatives. The following populations of data were evaluated: landfill gas, leachate at the seep, surface water in the East Landfill Pond, sediments in the pond, subsurface geologic materials (i.e., colluvium) downgradient of the landfill, subsurface geologic materials (i.e., weathered bedrock) downgradient of the landfill, and groundwater downgradient of the landfill.

Specific data sets used for each medium included the following:

- Landfill gas - 163 chemical-concentration measurements at 33 locations using field instruments that provide screening-level data (i.e., EPA Level II); one sampling event from Phase I RFI/RI.
- Landfill gas - *in situ* soil-gas sampling; 67 samples collected at 33 locations; one sampling event from Phase I RFI/RI (EPA Level IV and V).
- Leachate at the seep (SW097) - monthly data (1991); four months from Phase I RFI/RI (1992–1993) (EPA Level IV and V).
- Surface water in the East Landfill Pond (SW098) - monthly data (1991); four months from Phase I RFI/RI (1992–1993) (EPA Level IV and V).
- Sediments in the East Landfill Pond - three samples; one sampling event from Phase I RFI/RI (1993) (EPA Level IV and V).
- Subsurface geologic materials downgradient of the landfill - 21 samples from 2 boreholes (70993 and 71093), 7 from colluvium and 14 from weathered bedrock, one event from Phase I RFI/RI (1993) (EPA Level IV and V).
- Groundwater - quarterly data (1991–1995), four months from Phase I RFI/RI wells (1992–1993), four months from 1994 wells (1994–1995), quarterly data (2000–2001 and first quarter of 2002) (EPA Level IV and V).

Landfill gas data were not evaluated statistically. Environmental media upgradient of, or within, the source were not investigated. Information on contaminant distribution in surface soils, subsurface geologic materials upgradient of the landfill, surface water discharge from the north and south groundwater intercepts, groundwater upgradient of the landfill, and groundwater within the landfill is provided in the OU 7 Final Work Plan (DOE 1994).

28

2.9.1 Landfill Gas

Gas-flow through landfill waste and soils occurs in response to pressure gradients (i.e., advective flow), concentration gradients (i.e., diffusive flow), compaction and settling of wastes, barometric pressure changes, and displacement due to potentiometric surface fluctuations. Advection of landfill gas is typically the predominant transport mechanism. Off-gassing pressures up to 0.44 pounds per square inch (lbs/in²) were measured during the Phase I RFI/RI. Gas pressures exceeding approximately 0.05 lbs/in² indicate an advective, pressure-driven system.

The composition of landfill-generated gases was evaluated on the basis of screening-level data for total combustible gases, methane, and carbon dioxide. The composition of landfill gas at the Present Landfill is 45 to 70 percent methane, and 20 to 40 percent carbon dioxide, indicating anaerobic conditions. Concentrations of methane and carbon dioxide are highest in the eastern portion of the landfill where wastes are thickest and most recently disposed. In general, landfill gases appear to be contained within the existing groundwater interceptor system. Concentrations of methane and carbon dioxide are relatively low, as expected, in the vicinity of the gas-venting wells. Gas concentration maps and cross sections are included in the OU 7 Final Work Plan (DOE, 1994).

Concentrations of non-methane organic compounds (NMOCs) were determined by subtracting methane concentrations from the concentrations of total combustible gases. As a result, the reported concentrations of NMOCs may include minor amounts of inorganic gases such as hydrogen sulfide. Concentrations of NMOCs range from 0 to 152,000 milligrams per liter (mg/L) and average 30,000 mg/L.

Concentrations of NMOCs range from 0 to 152,000 milligrams per liter (mg/L) and average 30,000 mg/L.

In situ soil-gas sampling was performed to characterize hazardous air pollutants (HAPs) in the unsaturated zone of the landfill. Concentrations were reported as mg/L, but no corresponding emission rates for generated gases were reported. HAPs detected at the landfill include 1,2-dichloroethene, 1,1,1-trichloroethane, trichloroethene, methylene chloride, acetone, 2-butanone, toluene, xylene, and hydrogen sulfide.

Landfill gas generation was also evaluated during preparation of the conceptual design for the engineered cover (K-H 2001a). EPA's Landfill Emissions Model Version 2.0 (LANDGEM) was used to estimate total landfill gas emissions by estimating methane, carbon dioxide, and NMOC emissions individually and then summing the three model results. Results of the model indicated relatively low rates of landfill gas generation, with the majority (approximately 80 percent) of methane and total landfill gas production occurring by the year 2025, and almost all potential production by the year 2075.

2.9.2 Landfill Leachate at the Seep

The composition of landfill-generated leachate was evaluated on the basis of screening-level data collected during the Phase I RFI/RI and seep samples collected monthly during the Phase I RFI/RI and 1990-1991 surface water monitoring program. Because 1990 data were never validated, only 1991 data from this program were used. Twenty-six screening-level samples were collected from 16 locations. Methane concentrations in leachate from screening-level data ranged from 0.0003 to 31.4 mg/L and typically approached the solubility limit of 35 mg/L at 17 °C (Merck Index, 1989). Methane concentrations in leachate at the Present Landfill are consistent with methane concentrations of 25 mg/L observed at other landfills (Baedecker and Black 1979).

Surface water samples were collected from the seep at the base of the east face of the Present Landfill (SW097). Background comparisons were performed to identify PCOCs using the Gilbert methodology. Analytes detected in leachate at concentrations that exceeded background concentrations include metals,

radionuclides, and indicator parameters. VOCs and SVOCs were detected. The PCOCs and their associated concentration ranges, detection limits, detection frequencies, and qualifiers are summarized in Appendix A (Table A-1). Additional information is presented in the OU7 Final Work Plan (DOE 1994).

2.9.3 Surface Water in the Landfill Pond

The composition of pond water was evaluated on the basis of surface water monitoring samples collected monthly during the Phase I RFI/RI and the 1990–1991 surface water monitoring program. Because the 1990 data were never validated, only 1991 data from this program were used. Surface water samples representative of the landfill pond water were collected from station SW098. Metals and radionuclides were detected at concentrations or activities above background. VOCs and SVOCs were detected; however, none of the VOCs or SVOCs was detected frequently. The PCOCs and concentration ranges, detection limits, detection frequencies, and qualifiers are summarized in Appendix A (Table A-2). Additional information is presented in the OU 7 Final Work Plan (DOE 1994).

2.9.4 Sediments in the Landfill Pond

Sediment samples were collected at three locations in the pond. Samples were analyzed for VOCs, SVOCs, radionuclides, metals, and inorganics. None of the radionuclides exceeded background UTL_{99/99} values, and the only metal identified as a PCOC was zinc. Three VOCs and several SVOCs were detected in pond sediments. All SVOC results are estimated values below the quantitation limit (“J” qualified); however, they are still included on the PCOC list. The PCOCs and their associated concentration ranges, detection limits, detection frequencies, and qualifiers are summarized in Appendix A (Table A-3). Additional information is presented in the OU 7 Final Work Plan (DOE 1994).

2.9.5 Subsurface Geologic Materials Downgradient of the Landfill

Subsurface geologic materials were sampled in two boreholes to characterize potential leachate-contaminated materials downgradient of the landfill (70993 and 71093). Samples were collected at 2-foot increments in colluvium and 4-foot increments in weathered bedrock. A total of 21 samples were collected; 7 from colluvium and 14 from bedrock. All samples were analyzed for VOCs, SVOCs, PCBs, metals, radionuclides, and indicator parameters (total organic carbon [TOC], nitrate, and sulfide).

Background comparisons were performed to identify PCOCs using the Gilbert methodology (EG&G 1994b). Analytes that were detected at concentrations or activities above background include metals, radionuclides, and indicator parameters in colluvium and metals in weathered bedrock. SVOCs and VOCs were detected. The PCOCs and associated concentration ranges, detection limits, detection frequencies, and qualifiers are summarized in Appendix A (Table A-4). Additional information is presented in the OU 7 Final Work Plan (DOE 1994).

Calcium, magnesium, potassium, and sodium in colluvium and weathered bedrock are not considered PCOCs because they are essential nutrients. All SVOC results are estimated values below the quantitation limit (“J” qualified); however, they are still included on the PCOC list.

2.9.6 Groundwater Downgradient of the Present Landfill

Nine existing wells are screened across surficial material or weathered bedrock: three near the East Landfill Pond and six downgradient of the dam. Four wells are screened across unweathered bedrock sandstones or siltstones: one near the pond and three downgradient of the dam. Groundwater samples have been collected from the older wells since 1986 or 1989 and from the new wells since December 1994. Data from 1991 to 1995 were used in this report.

Background comparisons for inorganic analytes and radionuclides were performed to identify PCOCs. The results of the statistical tests for groundwater downgradient of the dam are summarized in Appendix A (Table A-5). In addition to the inorganic analytes and radionuclides that fail the statistical tests, all VOCs and SVOCs detected in groundwater are considered PCOCs unless eliminated by professional judgment.

Background comparisons for inorganic analytes and radionuclides were performed for LHSU groundwater to determine PCOCs. The results of the statistical tests for LHSU wells downgradient of the landfill are summarized in Appendix A (Table A-6). Calcium, magnesium, potassium, and sodium were not considered PCOCs because they are essential nutrients. The PCOCs remaining for LHSU groundwater downgradient of the landfill are barium (300 µg/L), lithium (87 µg/L), manganese (200 µg/L), molybdenum (17 µg/L), strontium (1,200 µg/L), acetone (8 µg/L), methylene chloride (3 µg/L), total xylenes (2 µg/L), bis (2-ethylhexyl) phthalate (4 µg/L), and butyl benzyl phthalate (4 µg/L). Given the hydrology of the unweathered bedrock, groundwater in the LHSU downgradient of the landfill will not receive further consideration.

Groundwater was also evaluated on the basis of screening-level data collected in 2000, 2001, and the first quarter of 2002. Groundwater quality at the Present Landfill appears to be generally consistent, with concentration trends for most analytes fluctuating but generally flat or declining. Monitoring indicates that landfill groundwater is not currently migrating past the East Landfill Pond dam. Specifically, fluoride, sulfate, total dissolved solids (TDS), calcium, lithium, magnesium, molybdenum, nickel, potassium, sodium, strontium, zinc, and uranium-235 concentrations in all downgradient wells do not appear to be increasing above historical levels.

The PCOCs and associated concentration ranges, detection limits, detection frequencies, and qualifiers are summarized in Appendix A (Tables A-7 and A-8). Additional information is presented in the 2000 Annual RFCA Groundwater Monitoring Report (DOE 2001) and in Evaluation of Groundwater Control Systems at the Present Landfill (K-H 2001b).

Significant differences in upgradient compared to downgradient groundwater quality exist for fluoride, sulfate, TDS, calcium, lithium, magnesium, molybdenum, nickel, sodium, strontium, zinc, uranium-233/234, uranium-235, and uranium-238. However, apart from fluoride, lithium, sulfate, zinc, uranium-233/234, and uranium-238 in Well B206989, the trends of potential inorganic and radionuclide contaminants do not appear to be increasing with time in the downgradient wells. The increasing trends of lithium, zinc, uranium-233/234, and uranium-238 in Well B206989 represent groundwater quality excursions that are reportable under the Site IMP. The elevated nitrate/nitrite, lithium, and selenium concentrations at Well B206989 do not appear to be landfill-related, as the concentrations of these analytes in landfill leachate and pond water have historically been relatively low. The most likely cause for anomalous groundwater quality at Well B206989 is an unknown secondary contaminant source located upgradient of Well B206889. There is also a small nitrate plume downgradient of the East Landfill Pond that may not be associated with the landfill.

A leachate/seep interception and treatment system was constructed in 1996 and modified in 1998 to collect and treat the leachate. Influent and effluent samples were analyzed for VOCs, SVOCs, metals, and radionuclides, but are currently only being analyzed for VOCs. The water discharging from the leachate treatment system into the East Landfill Pond meets all surface water action levels, except benzene on an intermittent basis. The benzene concentration was either 1 or 2 µg/L for all sampling events. The applicable RFCA standard is 1 µg/L.

A plume of VOC-contaminated groundwater is migrating from the PU&D Yard towards the Present Landfill. Alluvial groundwater containing the plume flows generally eastward across the pediment surface until it is intercepted by the GWIS, the No Name Gulch watershed to the northeast, or the North

Walnut Creek watershed to the south and southeast. Alluvial groundwater also enters into the GWIS at the landfill perimeter and may be discharged intermittently as surface water below the landfill pond dam into No Name Gulch. In addition, it is possible that some groundwater flow circumvents the groundwater interceptor system, enters landfill refuse material, and is ultimately discharged from the toe of the landfill at the seep. The distribution of contaminant concentrations within the PU&D Yard VOC plume indicates the principal groundwater flow pathway from the PU&D Yard is toward No Name Gulch. An in-situ treatability study was initiated in 2001 to remediate one of the source areas of the PU&D Yard plume.

3.0 PROJECT APPROACH

The Present Landfill is being addressed as an accelerated action under RFCA, which provides for the coordination of DOE's response obligations under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), and its closure and corrective action obligations under RCRA and CHWA. Closure requirements for the Present Landfill are contained in Attachment 10 to RFCA, which specifies that the landfill must be closed in place with an engineered cap or cover system designed to:

- Protect the most directly impacted surface water, and
- Control any remaining sources of groundwater contamination to the extent necessary to prevent enlarging the plume or increasing contaminant concentrations.

Engineered caps and covers are the presumptive remedy for CERCLA municipal landfill sites (EPA 1993). Such containment technologies are generally appropriate for municipal landfills because the waste poses a relatively low long-term threat to public health and the environment, and the volume and heterogeneity of the waste make treatment impractical.

Although the majority of waste disposed in the Present Landfill is considered municipal waste, some hazardous wastes were buried there and hazardous components have been detected in the leachate. As a result, the specific criteria used for the landfill cover design are based on a RCRA Subtitle C facility. The containment presumptive remedy consists of the following elements:

- Landfill cover (addressed in this IM/IRA),
- Landfill gas control and treatment, if required (addressed in this IM/IRA),
- Leachate collection and treatment, if needed (addressed in this IM/IRA),
- Source area groundwater control to minimize the plume (not addressed in this IM/IRA), and
- Institutional controls to supplement engineered controls (addressed in this IM/IRA with respect to installation of the landfill cover, landfill gas control/treatment, and leachate collection/treatment, only).

Response actions selected for individual sites include only those components necessary based on site-specific conditions. The containment presumptive remedy addresses all pathways associated with the source. As indicated previously, it is not known at this time if the Present Landfill is impacting groundwater or if contaminated groundwater could impact surface water. If a groundwater remedy is required, this IM/IRA will be modified in accordance with Part 10 of RFCA.

3.1 Cover Design Alternatives

As indicated in Appendix C of the RFCA Implementation Guidance Document (IGD) (DOE, CDPHE, EPA, 1999), an alternatives evaluation is not necessary if a presumptive remedy is selected. Therefore, a traditional alternatives analysis is not required for the Present Landfill. However, three variations of the presumptive remedy have been compared against the three IGD evaluation criteria: effectiveness, implementability, and relative cost. The results of this assessment are summarized in Table 1.

Table 1. Comparison of Design Alternatives

Design Option	Description	Effectiveness	Implementability	Relative Cost ^a
RCRA Subtitle C Cover	A two component low-permeability layer consisting of a 20-mil flexible membrane liner and a 60 cm compacted soil component with a maximum in-place saturated hydraulic conductivity of 1×10^{-7} cm/sec under a drainage layer (geosynthetic or natural) that will minimize water infiltration under a top layer of soil and vegetation or armored surface to minimize erosion.	Recent studies have indicated that conventional Subtitle C covers do not remain effective in semi-arid environments, such as Rocky Flats. Although groundwater monitoring is required to verify that the landfill is not impacting the surrounding environment, post-closure performance monitoring within the cover is not required to verify its effectiveness.	Subtitle C covers have been constructed since the 1980s. Although the process is time-consuming and difficult, requiring complex quality assurance, the methods required for construction are well established and there are many contractors capable of completing the construction.	Approximately \$160 per square meter for 20 acres \$12,949,952
ET cover w/ ET apron	A minimum thickness for the combined soil-rooting medium and erosion protection layers of 24 inches, with an average thickness of approximately 56 to 62 inches on top of a gas venting layer with an ET apron to minimize the seep.	Recent studies and the modeling conducted in the CDR indicate that an ET cover will be effective. The ET apron concept has not been modeled or used at other sites for controlling a seep. Performance monitoring within the cover and at the waste boundaries will be conducted to verify the cover's performance.	ET covers require different construction processes and equipment than conventional covers because the fill cannot be overcompacted. Although this process is new, it is not overly difficult and uses standard construction equipment.	Approximately \$74 per square meter for 26 acres \$7,786,159
ET cover w/ passive treatment system	A minimum thickness for the combined soil-rooting medium and erosion protection layers of 48 inches, with a maximum thickness of 60 inches on top of a gas venting layer, and reconstruction of the current passive treatment system on the east slope of the landfill.	Recent studies and the modeling conducted in the CDR indicate that an ET cover will be effective. Performance monitoring within the cover and at the waste boundaries will be conducted to verify the cover's performance. The current passive seep treatment system is effective.	ET covers require different construction processes and equipment than conventional covers because the fill cannot be overcompacted. Although this process is new, it is not overly difficult and uses standard construction equipment.	Approximately \$74 per square meter for 20 acres \$5,989,353

^a Cost figures taken from the *Alternative Landfill Cover Report*, DOE/EM-0558, December 2000.

The primary purpose of an engineered cover is to isolate landfill wastes by minimizing or preventing precipitation from infiltrating the landfill, contacting waste, and generating leachate. Conventional covers have been engineered as a barrier to precipitation infiltration by employing engineered fills and man-made materials. Alternative cover designs rely on soil physical properties, hydraulic characteristics, and vegetation to control or minimize the rate of water infiltration through the cover. Conventional covers, referred to as "RCRA Subtitle C caps," generally consist of the following elements, from bottom to top:

- A two-component low-permeability layer consisting of a 20-mil flexible membrane liner and a 60 cm compacted soil component with a maximum in-place saturated hydraulic conductivity of 1×10^{-7} cm/sec;
- A drainage layer (geosynthetic or natural) that will minimize water infiltration; and
- A top layer of soil and vegetation or armored surface to minimize erosion. Optional layers, based on site-specific needs, include a gas venting layer to remove gases generated within the waste material and a biota barrier layer to protect the cover from animal or plant intrusion.

Initially, a Subtitle C cap was considered for the Present Landfill; however, recent and ongoing studies are showing that barrier caps are susceptible to failure, especially under the arid and semi-arid environmental conditions typical in the western United States.² Clay barrier layers, which require the clay to be installed at or above optimum moisture to meet the permeability requirements, are prone to desiccation and cracking in drier environments. Once this layer cracks, there is a flow path for precipitation into the landfill. Subtitle C caps require performance monitoring to verify that contaminants are not migrating from the landfill, but there are no requirements for performance monitoring within the cover to verify the cover's effectiveness after construction. Also, conventional covers are more expensive and difficult to construct than alternative covers.

A conceptual design prepared during calendar year (CY) 2001 proposed an evapotranspiration (ET) cover for the Present Landfill (K-H 2002a).³ ET covers generally consist of a uniform, monolithic soil layer, which achieves infiltration reduction performance by storing soil moisture until it is removed through the natural processes of evaporation and plant transpiration. Establishment of sustainable vegetative communities is promoted, thereby minimizing wind and storm water erosion from the cover surface.

The primary functional component of an ET cover is the soil-rooting medium. An erosion protection soil layer covering the soil-rooting medium is used to promote the establishment of vegetation and prevent erosion. These combined soil layers function together as a thick soil-rooting medium, to store soil moisture and allow vegetation to use and remove the moisture, thereby preventing percolation. The conceptual design proposed a minimum thickness for the combined soil-rooting medium and erosion protection layers of 24 inches, with an average thickness of approximately 56 to 62 inches, based on the cover layout design grades. In addition, the conceptual design included a gas-venting layer below the soil-rooting medium to allow the passive release of methane and provide a well-oxygenated root zone in the venting layer and overlying soil to promote vegetative growth.

The conceptual design also provided an option to construct an ET apron on approximately 6 acres at the eastern end of the Present Landfill to minimize the seep. The ET apron included flow control structures to

² Field studies conducted in association with EPA's Alternative Cover Assessment Program (ACAP) have provided data substantiating the performance of ET covers in the Western United States. Conventional Subtitle C cover designs have significant drawbacks for application at the Present Landfill. For example, synthetic flexible membrane liners have an uncertain longevity and may not achieve the desired design life, and compacted clay covers desiccate and crack in semi-arid conditions. Therefore, the conceptual design for the Present Landfill is an ET cover. For details concerning the performance of ET covers, see Update on Testing and Monitoring Requirements for Alternative Landfill Covers in the Western United States (K-H 2002c), which is included as Appendix C of the Conceptual Design for the Present Landfill Cover (K-H 2002a).

³ The conceptual design is being used as the 30 percent design for the Present Landfill cover.

distribute water flow in the area of the existing landfill seep consisting of French drain type rock and gravel filled trenches to provide pathways for passive flow in the shallow groundwater system. The trenches would provide high transmissivity pathways to distribute water across the surrounding area.

In addition, the conceptual design proposed a three-phase performance monitoring program to verify the effectiveness of the cover to prevent infiltration of precipitation into the landfill. This performance monitoring program would be in addition to the monitoring required for RCRA post-closure monitoring (i.e., groundwater monitoring) at the waste boundary.

The Conceptual Design Report (CDR) for the Present Landfill (K-H 2002a) was distributed for consideration by EPA, CDPHE, and the stakeholders in April 2002. As a result of subsequent, informal consultations, the direction of the design effort was shifted to a cover that minimizes infiltration of precipitation into the landfill while also minimizing the impact to the area around the landfill (i.e., No Name Gulch). The following objectives were developed for subsequent cover design activities:

- Protect surface water per RFCA,
- Close the RCRA interim status unit and meet CERCLA requirements (the presumptive remedy for landfills is a cap or cover),
- Minimize adverse impacts associated with the closure/accelerated action, and
- Create a stable configuration consistent with the anticipated wildlife refuge future use.

Based on these objectives, and in consultation with the regulators and stakeholders, many changes will be made to the conceptual design in the subsequent design documents (i.e., 60 percent, 90 percent, 100 percent designs). For example, the CDR proposed implementation of an ET apron to minimize or eliminate the seep, but the seep is currently being treated with a passive system that generally meets the design concentration limits (DCLs) for impacted surface water. As a result, it was determined that an additional 6 acres of land should not be disturbed to construct the ET apron, and instead, the existing passive treatment system should be rebuilt on the new slope of the landfill cover. The system will be lengthened to address instances where the system has failed to meet the surface water standard for benzene.⁴ The 60 percent design for the ET cover will be developed using the following guidelines:

- The asbestos will not be relocated.
- Grade fill will be placed on the landfill prior to placement of the gas venting layer so that the cover (soil rooting medium and erosion protection layer) will be no more than 5 feet thick.
- The cover will have a minimum 3 feet of soil rooting medium and a 1-foot erosion protection layer.
- The ET cover will be placed over all of the waste.
- The ET cover will have slopes between 3 and 5 percent.
- Side slopes that are not over waste will be designed for slope stability and erosion protection.
- The gas venting layer will be designed to also act as a biota barrier, which will require a thicker layer with larger cobbles.
- The ET apron will not be constructed. Instead, the existing passive seep treatment system will be extended to the new east slope surface.
- The pond and wetlands east of the landfill will not dictate the design of the remedy, but the impacts will be minimized, if possible. If it is not possible to maintain any portion of the pond

⁴ See Attachment 5 to RFCA, Action Levels and Standards Framework (ALF) for Surface Water, Groundwater, and Soils.

and wetlands, the dam will be removed and used as grade fill, and the area will be re-contoured to be consistent with the topography of No Name Gulch.

During further development of the design, two formal design reviews will be conducted: a 60 percent review and a 90 percent review. At a minimum, the 60 percent review will include a narrative description of the cover design; UNSAT-H modeling results; design drawings; Construction Specification Institute (CSI) specifications; costs; and a project schedule. The 60 percent design will be prepared using the consultative process, and monthly meetings will be held to discuss the design progress and resolve any outstanding issues. The 90 percent review will include all information necessary for construction of the cover, lacking only the incorporation of final comments the regulatory agencies and stakeholders.

3.2 Project Planning & Execution

Construction methods for each component in the ET cover will use standard construction equipment. The majority of the construction effort will be earthwork to place the soil-rooting medium, erosion protection, and aggregate layers. Throughout the construction process, quality assurance/quality control (QA/QC) measures will be implemented to ensure the design specifications are met. The construction contractor will prepare a Construction Quality Control (CQC) Plan detailing the activities and processes that will be conducted to implement the QC requirement for the final design. An independent firm will be responsible for QA, which includes checking the conformity of the work and providing documentation to show that the work was completed in accordance with project drawings and specifications. The construction process required for the Present Landfill cover is described in the following sections.

3.2.1 Mobilization

Cover construction will begin with the mobilization of the construction contractor, followed by site preparation. A laydown area will be established on the south-southeast side of the Present Landfill, and if soil stockpiling is conducted, an area will be prepared on the north-northwest side of the landfill. The construction contractor may mobilize the following items: office trailers, shower facilities, lunchroom, portable toilets, hand wash units, and tool/equipment storage. A fence may be installed for overall access control.

3.2.2 Site Preparation

Site preparation involves protecting permanent features; establishing temporary storm water controls, equipment patterns, and haul roads; removing the existing gas venting system; and clearing and grubbing vegetation. Before mobilizing equipment, protective barriers or fences will be erected around permanent Site features designated to remain after construction. As necessary, run-on and run-off control features will be implemented; temporary diversion berms, erosion control silt fencing, and interceptor ditches will be installed; and existing drainage culverts and ditches will be cleaned out as required to divert significant overland flow away from the construction site. The installation of run-on and run-off control features will be coordinated with Environmental Systems & Stewardship (ESS) personnel responsible for the surface water monitoring system surrounding the Present Landfill site.

Equipment traffic patterns and stockpiling areas will be established. For any material that will be stockpiled for a long period of time, a more permanent area will be created and additional erosion and/or run-on and run-off controls will be implemented, as necessary. Haul roads may be required to facilitate material movement. Whenever possible, existing roads will be used and improved instead of disturbing new areas.

Grade control markers will be established. Grade control provides for proper placement of construction materials in accordance with the final design documents. Independent survey verification will be used to

spot-check grades and material thicknesses as a quality control measure. The grade control survey also provides as-built quantity determinations for payment to the construction contractor.

A series of gas vents were installed in the interim landfill cover in 1997. The existing vents consist of vertical standpipes that extend into the underlying waste to allow passive venting of landfill gas. These existing vents will be removed before construction of the ET cover. Removal of the vents will be accomplished by pulling the casing or by plugging the casing with bentonite or grout. If the casing is left in place, it will be cut off below ground surface. The existing gas vents will not be needed following installation of the ET cover gas-venting system.

Before earthwork is initiated by the construction subcontractor, areas where the cover will be placed will be cleared and grubbed. Existing vegetation will be stripped to provide consistent adhesion between the existing soils and the overlying soil materials placed for cover construction. Clearing and grubbing will be conducted using a phased approach to minimize dust generation.

In the event the final design results in the elimination of the Present Landfill pond, the pond and dam will be removed before the cover is constructed.⁵ The pond is located approximately 100 feet from the toe of the eastern slope, and a wetland begins adjacent to the toe of the slope and extends to the dam crest, approximately 600 feet to the east. To meet design requirements for an east slope that is stable and will resist erosion, the eastern slope may extend beyond the existing landfill slope and infringe on the pond and wetland. This earthwork will be completed during cover construction, at the same time a thick wedge of soil is placed over the existing east slope of the landfill. If the East Landfill Pond and dam are removed, the water in the pond will be discharged appropriately. The pond water will be assessed for use as dust control water. If the water is not suitable for dust control, it will be transferred to the A-Series Ponds or Building 891 for treatment. The pond sediments will also be sampled to ensure the material can remain in place. If the pond sediments are above RFCA Tier I action levels, the sediments will be removed and appropriately disposed. If the pond sediments are between Tier I and II action levels, the consultative process will be used to determine how the sediments will be dispositioned. Once the water and sediments have been sampled and dispositioned, the dam will be removed and used as fill material for the landfill cover.

3.2.3 Gas-Venting/Biota Layer Placement

The gas-venting/biota layer will be constructed of clean gravel, free of fines, to ensure good airflow through the layer. The gravel will be a processed, screened material, either imported from an offsite commercial source or excavated and processed onsite, as described in Section 3.2.5. Sieving will be adequate, since the presence of some fines will not significantly change permeability. The material will be placed and spread in accordance with standard earthwork practices.

Piping installation for the passive landfill gas-venting system will generally follow standard industry practices for installation of landfill gas collection system piping for active landfill extraction systems. Field fusion of high-density polyethylene (HDPE) pipe will be conducted by qualified personnel and will meet the QC and testing requirements specified in the final design.

A geotextile separation fabric will be installed above the landfill gas-venting/biota layer to prevent intrusion of fines from the overlying soil-rooting medium. The geotextile will be deployed in rolls and the individual panels will be seamed together using portable stitching equipment. Material requirements and certification and QC testing will be documented in the final design documents.

⁵ An "Application for Removal or Breach of a Dam" will be completed and submitted to the Colorado Division of Water Resources prior to removal of the Present Landfill Pond dam.

3.2.4 Soil Excavation, Processing, and Transportation

The soil source for the cover material is currently being assessed. There are 2 options for the soil: an onsite borrow source and a commercial offsite borrow source. Onsite soils may be taken from re-grading activities (e.g., if the dam is removed, the soil may be used for the cover). An offsite commercial source has been located at the LaFarge quarry, approximately 2.5 miles from RFETS. The 60 percent design effort will evaluate and select the borrow area(s) based on the suitability of the soil and economics associated with obtaining the soil.

If an onsite borrow source is used, the material may need to be processed to remove gravel and cobbles. Soil and aggregate processing may be set up to screen rock and aggregate materials for use in the erosion protection layer and gas-venting/biota layer. It is anticipated these soils contain significant cobble and gravel percentages, and appear suitable for processing based on nearby commercial quarrying and processing of similar soils.

The construction contractor's choice of excavation equipment will depend on the distance between the borrow source and the Present Landfill site, and on the geotechnical characteristics of the soil. Based on the material quantities, transportation of the main cover construction materials may require many thousands of truckloads of material. The haul distance from the offsite quarry will have a significant impact on the construction cost, and costs are expected to rise dramatically if transportation distances become excessive.

Two previous reports, (EG&G 1994, K-H 1996), provide additional information on transportation issues. The EG&G report evaluates borrow sources, including transportation over public highways and the locations of many of the commercial quarries operating in the area in 1994.

3.2.5 Soil Placement

The Present Landfill cover will be constructed in a manner that limits compaction, which will require the careful selection of placement equipment and establishment of haul routes. This is important for the establishment of vegetation, which requires specified densities to permit optimum root growth and maximize water-holding capacity. Soil compaction will be limited to approximately 80 to 90 percent of standard proctor density, which will be specified in the final design documents. Minimal soil compaction will be achieved using tracked or low-weight wheeled vehicles in combination with the placement of thicker lifts. Excessive compaction of certain portions of the construction site will occur as a result of temporary haul roads and vehicle traffic. As needed, any over-compacted areas will be loosened to meet the compaction requirements.

Soil compaction during placement will depend largely on the moisture content of the cover material. Therefore, soil moisture will be monitored throughout the placement activity and may be a factor in selecting the borrow source. Soils observed at the nearby LaFarge quarry are relatively moist in the shallow and deep soil profile. Based on these limited observations, RFETS soils appear to be in the range of optimum moisture, which indicates they will tend to compact significantly during routine construction. Specifying and controlling soil moisture during construction can limit the degree of compaction, but only if soil moisture is significantly drier than optimum. Drier or processed soils may need to be imported to meet the applicable specifications. As a practical consideration, drying of soils in the quantities needed may be difficult to achieve or control. However, a combination of construction methods to limit soil compaction and final discing and processing as needed to loosen the soil, may be used to achieve the applicable soil density specifications.

Throughout the soil placement activities, QA/QC testing will be conducted. Testing will be conducted to ensure the soils and soil placement activities meet the applicable design requirements. QC testing will be

conducted by the construction contractor at the frequency specified in the final design. QA testing will be conducted by an independent contractor at the frequency specified in the final design.

3.2.6 Passive Seep Treatment System

During site preparation, the existing passive treatment system will be configured to manage the water during construction of the cover, and the components of the old system will be abandoned in place. It is anticipated that water from the seep will be collected in a portable tank. The containerized water will be sampled and managed in accordance with the Site's Incidental Waters Program (K-H 2001b).

During construction of the Present Landfill cover, the seep treatment system will be extended to the new eastern slope surface. The water will be discharged over a set of flagstones to allow for aeration. Depending on the final design, the treated water will be discharged into the reconfigured pond or into No Name Gulch. The passive aeration system will be longer than the current system to allow for additional volatilization of VOCs.

3.2.7 Performance Monitoring Equipment

The final design will specify the monitoring locations and equipment required to assess cover performance. The monitoring equipment will be installed in accordance with the final design documents. Soils surrounding the monitoring systems will be hand-compacted in accordance with the applicable design specifications to ensure the required soil densities are achieved.

3.2.8 Revegetation

The final design documents will include a revegetation plan, which will meet K-H Ecology Group requirements. Either drill seeding or hydroseeding may be used. In addition, mulching and crimping will be used, as needed, to temporarily stabilize the soil surface until plants germinate and become established. Soil amendments, if needed to provide added nutrients and organic matter, will be tilled into the soil at specified depths as soil placement occurs. The soil used for the erosion protection layer may be a processed material, with rock and gravel added for erosion resistance. Soil amendments could be added to this topsoil during processing, by either mixing or tilling the soil. The flatter surfaces of the landfill cover will be covered with straw and a straw crimper will be used to crimp the straw into the soil. Crimping the straw into the soil will help control erosion and provide a microclimate that promotes germination of the grass seed.

3.2.9 Site Cleanup and Demobilization

Demobilization will occur throughout the project, as various activities are completed and equipment is no longer needed. Because some re-grading of the existing grade fill surface will be necessary before placement of ET cover soils, some equipment may encounter landfill waste. Any equipment that encounters landfill waste will be decontaminated, if necessary. Project completion will require the disconnection and removal of all temporary utilities from the site, as well as the removal of support area facilities and materials. Disturbed areas will be graded and revegetated after being vacated.

3.3 Project Controls

The Present Landfill cover will be designed and constructed in accordance with the RFETS ISMS, which provides the framework for ensuring that all work performed at RFETS is planned, analyzed, reviewed, approved, and performed safely. ISMS is implemented through a variety of existing sitewide programs,

as summarized below. More detailed information regarding the work planning and implementation process is provided in the Environmental Restoration Operations Plan (EROP) (K-H 2002d).

3.3.1 Integrated Work Control

ISMS is implemented at the activity level through the Integrate Work Control Program (IWCP) per the requirements of the IWCP Manual (K-H 2000a). The IWCP Manual requires prior planning to define the scope of work, identify and analyze the hazards, identify and implement the appropriate work controls, and provide feedback for continuous improvement through the process.

Prior to initiating the proposed action, the project team will walk down the project site to document existing conditions, detail the permits required for implementing the project, and detail the Site organizations that must be involved in the planning process. The walkdown will provide sufficient information which, when combined with available historical information, will allow for the completion of the applicable work control documents, including the programmatic Field Implementation Plan (FIP) and project-specific FIP Addendum. The FIP Addendum will describe the specific approach that will be used to implement the proposed action.

3.3.2 Readiness Determination

The proposed action will not begin until it has been brought to a state of readiness to conduct the work safely, and the state of readiness has been verified. For readiness purposes, ER performs a Management Assessment of Readiness (MAR) in accordance with Management Assessment of Readiness (K-H 2001c).

3.3.3 Quality Assurance

The work associated with the proposed action will be performed in accordance with the requirements of 10 CFR 830.120, Quality Assurance Requirements (the QA Rule); DOE Order 414.1, Quality Assurance; and the American National Standards Institute/American Society for Quality Control (ANSI/ASQC-E4). Applicable QA requirements are described in the ER Program Quality Assurance Program Plan (K-H 2001d).

3.3.4 Conduct of Operations

The RFETS Conduct of Operations (COOP) Program (K-H 2000b) provides a formal, disciplined approach to facility operations. The proposed action will be performed in compliance with applicable COOP requirements, which are summarized in the COOP Checklist provided in the EROP. The COOP Checklist is completed by the ER Project Manager as part of the MAR.

3.3.5 Worker Health & Safety

The Site's Occupational Safety & Industrial Hygiene (OS&IH) Program (K-H 2000c) ensures that personnel exposures to physical, chemical, and biological hazards in the work environment are controlled by requiring job supervisors and OS&IH personnel to identify OS&IH hazards in the work area.

Program safety and technical reviews are integrated into the work control process to ensure non-radiological OS&IH hazards (i.e., physical, chemical, biological) are identified and appropriate measures are instituted to protect the worker (e.g., engineered systems, personal protective equipment [PPE], personnel monitoring). The OS&IH Program incorporates the standards defined in 29 CFR Parts 1910 and 1926, and DOE regulation 10 CFR 850.

To ensure compliance with applicable OS&IH requirements, the project will be conducted in accordance with the approved programmatic Health & Safety Plan (HASP), and associated project-specific HASP Addendum.

3.3.6 Emergency Preparedness

The RFETS Emergency Preparedness Program provides the plans, procedures, and resources necessary to respond to Site emergencies. The Program is based on a comprehensive understanding of the potential hazards and potential radioactive material and hazardous chemical release mechanisms present in the facility. Elements of the Program include management planning; training; and drills for possible abnormal events, including fires, hazardous material spills, and personnel accountability during facility evacuation. The Program's trained emergency response personnel ensure worker and public safety during an abnormal event. Elements of the Emergency Preparedness Program also include timely notifications of the emergency preparedness organization. The Emergency Preparedness Program is implemented through the Site Emergency Plan, as augmented by building-specific and project-specific emergency response operations procedures.

3.3.7 Environmental Management

The proposed action will be monitored by Site environmental management organizations. Project environmental management staff and the ESS organization use the RFETS Environmental Checklist to identify activities that may impact any of the Site's media-specific environmental programs. ESS implements the Site IMP, (DOE 2000a), which specifies monitoring requirements to protect air, water, and ecology. Issues relating to the Site's National Pollutant Discharge and Elimination System (NPDES) permit and incidental waters are administered through the Remediation, Industrial Area Decommissioning and Site Services (RISS) Project.

RFCA mandates incorporation of NEPA values into all RFCA decision documents. The RFETS NEPA group has completed the required environmental impact analysis for the proposed action, including the cumulative impacts of characterization and remediation activities on sitewide closure activities and other major federal actions occurring within the vicinity of the Site. The results of this analysis are contained in Section 5.

Routine, site-wide monitoring will be conducted during performance of the proposed action. The Air Quality Management group maintains the RFETS Radioactive Ambient Air Monitoring Program (RAAMP), which monitors the perimeter of RFETS continuously with samples collected and analyzed on a monthly basis. The RAAMP sampling network also includes monitoring stations inside the perimeter of RFETS, which are collected but not analyzed unless conditions warrant additional analysis.

3.3.8 Waste Management

Wastes generated as a result of the proposed action will be limited to office trash and other sanitary wastes. The various waste streams are described in the Waste Stream and Residue Identification and Characterization (WSRIC) Book for OU Operations. Wastes generated as a result of the proposed action will be accumulated, characterized, packaged, inspected, and staged for offsite shipment in compliance with the Environmental Restoration Program Waste Management Plan (K-H 2002e).

3.4 Working Relationships

As owner of the Site, DOE oversees closure operations; provides input to the contractor regarding funding and overall direction; and communicates with the regulators and other stakeholders (e.g., the Rocky Flats Citizens Advisory Board [RFCAB], the Rocky Flats Coalition of Local Governments [RFCLOG], and the public) regarding the status of ER activities.

The Kaiser-Hill Company, L.L.C. (K-H) is the Contractor charged with closing the Site in accordance with RFCA and the Rocky Flats Closure Project Baseline (CPB).

EPA is the LRA for the Buffer Zone, and is thus the LRA for remediation of the Present Landfill. CDPHE is the SRA for the Buffer Zone, but has primary responsibility for RCRA closure activities. As a result, both CDPHE and EPA will oversee the planning and implementation of the proposed remedial action.

The personnel of DOE, its contractor and subcontractors, and the regulators (i.e., CDPHE, EPA) will use the RFCA consultative process to establish and maintain effective working relationships with each other and with stakeholders during the design and implementation of the proposed remedial action.

43

4.0 RCRA UNIT CLOSURE

The Present Landfill will be closed to minimize the need for further maintenance and control; and to minimize or eliminate, to the extent necessary to protect human health and the environment, post-closure escape of hazardous waste, hazardous constituents, leachate, contaminated run-off, or hazardous waste decomposition products to the ground or surface waters or to the atmosphere.

4.1 Notification of Closure

This IM/IRA serves as notification to EPA and CDPHE of the pending closure of the Present Landfill. No specific form is required for notification of closure.

4.2 Closure Activities

The construction specifications for the Present Landfill cover are summarized in Section 3.5 and will be presented in detail in the final design documents. The construction contractor will be held in strict conformance to the final construction design drawings and specifications.

QA/QC inspection and testing will be performed during construction of the ET cover in accordance with the CQC Plan that outlines specific inspection and testing requirements for all materials and construction performance, necessary documentation, procedures for correcting nonconforming items, and the party responsible for each aspect of CQC. All materials and placement of materials for the cover will be subject to inspection and testing to assure conformance to the specifications.

Ancillary activities performed concurrently with construction of the ET cover will include wetlands mitigation, surface water management, and site security. Compensatory mitigation for unavoidable impacts to wetlands will be provided in accordance with the applicable or relevant and appropriate requirements (ARARs). Surface water run-off will be controlled by grading the surface of the landfill. Surface water will drain to the perimeter drainage ditches and routed to No Name Gulch.

The water level in the East Landfill Pond will be lowered to allow better access for construction activities during closure and to allow for removal of the East Landfill Pond dam by transferring water to the A-Series ponds. Leachate management and landfill gas monitoring will be performed as a continuation of the accelerated action until construction of the ET cover begins.

Site security will be maintained during and after construction activities. A chain-link fence surrounds the Present Landfill, prohibiting access by unauthorized personnel. Gates will be installed for construction access. Signs will be posted warning of potential danger at the landfill.

4.3 Closure Documentation

RCRA closure activities will be documented in the Closeout Report, as described in Section 8.0.

44

5.0 POST-CLOSURE CARE

Post-closure controls, monitoring, and maintenance will be implemented at the Present Landfill, as described in the following paragraphs.

5.1 Institutional Controls

Site security and access controls will be maintained until completion of the RFETS Closure Project, currently scheduled for December 2006. In accordance with the Rocky Flats Wildlife Refuge Act of 2001 (Act), (Pub.L. 107-107, Sec. 3171-3182, [December 28, 2001]), DOE will retain control over the Present Landfill site even after RFETS is transferred to the U.S. Fish and Wildlife Service (USFWS) within the U.S. Department of Interior (DOI).

5.2 Monitoring & Maintenance

Following construction of the ET cover, monitoring and maintenance activities will be performed to include the following:

- Installation of groundwater monitoring wells around the edges of the Present Landfill, and collection of groundwater samples from new wells and existing wells;
- Installation and monitoring of gas vents;
- Installation and monitoring of surface water monitoring stations to evaluate the performance of the passive seep treatment system;
- Installation of performance monitoring points within the ET cover, and monitoring of this system to evaluate the actual performance of the cover;
- Inspection and maintenance of the ET cover to evaluate the quality of the vegetation and to repair any cover damage, including excessive erosion such as rills;
- Additional monitoring and/or other activities required to evaluate the performance of the ET cover.

5.2.1 Groundwater Monitoring

This section describes the proposed groundwater monitoring program for post-closure activities. Groundwater monitoring will be conducted to satisfy the post-closure care requirements of Part 265.310 of RCRA/CHWA.

One upgradient well and three downgradient monitoring wells will be required for post-closure groundwater monitoring. New wells will be installed around the waste management area (i.e., the area over which waste has been placed). These wells will be used as points of compliance. The point of compliance is defined as the vertical surface that extends down into the UHSU at the downgradient limit of the waste management area. Compliance will be based on generally declining contamination levels. The wells will be used primarily to determine if contaminants that have the potential to impact surface water are leaching from the landfill.

Well locations will be finalized during the design process, and will be as close to the limit of waste placement as practical, based on the cover design grades. At a minimum, three wells will be placed downgradient, on the east side of the landfill, and one well will be placed upgradient, on the west side of the landfill. Downgradient well locations will ensure that contaminants are detected if they migrate away

from the source and provide information regarding improvement or degradation of groundwater quality. Once the locations are selected, a well location map will be added as a minor modification to this IM/IRA.

There is minimal potential for human exposure to contaminated groundwater at the Present Landfill. Future land use for the BZ, which includes the area downgradient of the landfill, is anticipated to be a wildlife refuge. Groundwater will not be used as a source of drinking water. Institutional controls will prohibit future development of groundwater. In addition, No Name Gulch is a “losing stream” year-round, which means vertical gradients are downward and surface water recharges the groundwater in the UHSU. Groundwater is not discharged to surface water in No Name Gulch.

Once the well locations are selected, the wells and monitoring requirements will be incorporated into the Site IMP (DOE 2000a). Data sampling and reporting from these wells will be consistent with the IMP methodology. Groundwater samples will be collected quarterly for one year and annually thereafter for water quality parameters; semiannually for indicator parameters. Water quality parameters include chloride, iron, manganese, sodium, and sulfate. Indicator parameters include pH, specific conductance, total organic carbon (TOC), and total organic halogen (TOX).

The groundwater monitoring data will be reviewed and analyzed to evaluate groundwater quality at the Present Landfill. New groundwater data will be compared to historical data to detect trends in potential groundwater contamination. Statistical analytical methods will be used to determine if significant changes in contaminant concentrations occur within individual wells, within well groups, and within the monitoring system. Following are the decision criteria that will be used to evaluate the performance of the groundwater monitoring wells. The decision process is depicted in Figure 4.

Problem Statement:

Have concentrations of contaminants in downgradient monitoring wells exceeded the mean concentrations in upgradient monitoring wells at RCRA units?

Problem Scope:

RCRA monitoring is conducted to detect potential excursions of contamination that are below the point of compliance established for RCRA units on Site. RCRA units are considered to be any units regulated under 6 CCR 1007-2 solid waste requirements. Attachment 10 to RFCA will be followed in determining points of compliance and alternative concentration limits affecting these units.

Inputs:

- Unit-specific potential contaminants of concern (PCOCs)
- Field parameters
- Water levels

Boundaries:

Spatial: Decisions will be made based on pooled results of upgradient wells and on an individual well basis in downgradient wells. If there is insufficient data to do downgradient comparisons on a per well basis, then a pooled data set will be used.

Temporal: Data will be reviewed and upgradient/downgradient comparisons will be made annually. However, because downgradient wells are in a drainage, they will also be evaluated and reported as drainage wells quarterly.

460

Decision Statement:

IF Mean concentrations in any downgradient well exceed the mean concentration in upgradient wells by more than two standard deviations of the data set,

AND Concentrations at any downgradient well increase with time,

THEN Report to appropriate agencies and investigate possible causes,

ELSE Continue monitoring.

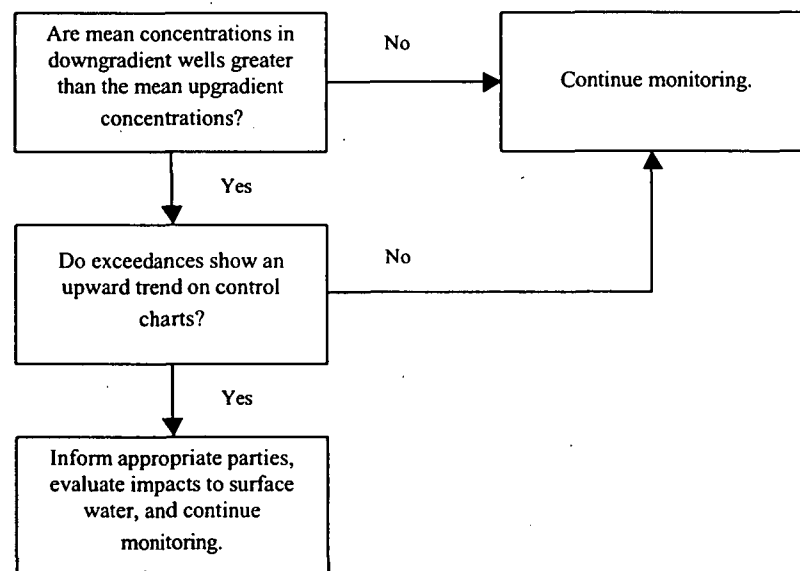


Figure 4. RCRA Groundwater Monitoring Decision Tree

5.2.2 Gas Vent Monitoring

Landfill gas monitoring will be performed quarterly using the system of passive gas vents installed within the ET cover. The objective of the gas monitoring program is to monitor emissions to ensure that gas treatment is not needed. Gas monitoring will be performed in accordance with the requirements of 40 CFR 258.23.

Gas monitoring will be performed manually at each gas vent location using a portable combustible gas indicator (CGI) and a photoionization detector (PID) or equivalent. The CGI will be used to detect and measure the concentration of combustible gases and oxygen levels to quantify the explosive potential and levels of asphyxiant gases and vapors. The PID will be used to detect and measure total volatile organic compounds. A hot wire anemometer or equivalent, will be used to obtain gas-flow measurements.

Quarterly gas monitoring data will be used to evaluate the effectiveness of the passive gas collection system at the landfill and to assess compliance with air emission requirements under Colorado Air Quality Control Commission (CAQCC) Regulation No. 3.

5.2.3 Surface Water Monitoring

Depending on the final cover design, the East Landfill Pond may be modified or completely eliminated. Currently, the pond is discharged by pumping the water to the A-Series ponds, which are monitored through a series of surface water sampling and flow monitoring locations. If the pond is eliminated in the final design, and the passive seep treatment system is discharged directly into No Name Gulch, a new surface water monitoring station will be installed to verify the performance of the system. Once the surface water monitoring location is selected, the monitoring station requirements will be incorporated into the Site IMP (DOE 2000a).

The surface water monitor will utilize the enhanced monitoring option from the IMP (DOE 2000a). An automated sampler will collect flow-paced composite samples that will monitor the location-specific contaminants of concern. The contaminants of concern for future performance monitoring and their associated limits are presented in Table 2.

Analyses will be performed for each of the contaminants and parameters listed below to establish a baseline. After a baseline has been established, evaluations will be performed as required by the decision rules.

If the mean concentration of any of the screening indicator variables in Table 2 exceeds the 95% UTL of the baseline for that variable, the Site will evaluate the need for further action under Attachment 5 to RFCA, (e.g., source evaluation and control).

The baseline is defined by an average value for the parameter of interest over all monitored precipitation events for a single baseline year, at the discretion of DOE. A single measured value is accepted as representing a contaminant of interest. If a single measured value exceeds the 5% UTL of baseline, that will provide adequate confidence of new source detection and invoke the actions specified by the decision rule.

Table 2. Seep Treatment System Water Analytes and Performance Standards

VOC Analytes	RFCA Surface Water Standard (µg/L) ^a
Cis 1,2-Dichloroethene	70
Benzene	1
Chloromethane	5.7
Ethylbenzene	680
Methylene Chloride	5
Tetrachloroethene	1
Toluene	1,000
Trichloroethene	2.7
Vinyl Chloride	2
Xylene (Total	10,000

^a RFCA values are from Attachment 5, Table 1, Surface Water Action Levels and Standards, March 2000.

5.2.4 Performance Monitoring

The performance of the ET cover will be monitored following completion of cover construction. The objective of performance monitoring is to provide a means to assess the hydrologic performance of the cover based on in-situ measurements of soil hydrologic parameters and drainage rates. Hydrologic parameters will be measured to:

- Assess seasonal and annual soil moisture conditions throughout the profile of the ET cover;
- Calculate seasonal and annual vertical flow rates based on in situ measurement of hydraulic potentials/gradients in the cover; and
- Quantify total percolation rates through the cover by collecting and measuring water that has migrated to the base of the lysimeters.

Monitoring locations will be selected and documented in the final design documents to demonstrate a variety of slope conditions, including varying slope aspects and positions along the slope. The soil moisture condition within the ET cover and associated plant productivity are influenced by microclimates that result from variations in environmental conditions including wind, temperature, solar radiation, and water distribution. The localized slope of the ET cover has the most potential to affect environmental conditions. The slope aspect affects exposure to solar radiation, which also affects the soil moisture condition, since north-facing slopes are exposed to less solar radiation as compared to south-facing slopes. The location along the slope also affects environmental conditions since upslope locations are subject to less moisture from run-off and more evaporation due to exposure to wind as compared to downslope locations.

Phase I hydrologic cover performance monitoring will be conducted for the first 6 years following installation of the ET cover. Performance monitoring for the outlying years will include two additional phases. Phase II will be conducted during years 7 through 10, and Phase III will be performed during years 11 through 30. Phases II and III will include less stringent monitoring requirements than the Phase I requirements.

The monitoring strategy for the ET cover following the initial, 6-year, Phase I monitoring period, will be based on data collected during the past 6 years, a consideration of new technological advances, and an evaluation of any new research relating to ET cover performance. Factors considered in the development of Phase II and Phase III monitoring of the ET cover will include, but need not be limited to:

- The overall hydrologic performance of the ET cover;
- The suitability of the monitoring systems to assess overall hydrologic performance based on site conditions;
- The spatial and temporal variability of the vegetative cover and related ET cover hydrologic response;
- The application of a calibrated UNSAT-H water balance model using model input parameter values obtained from in-situ measurements (i.e., hydraulic characteristics, boundary condition, plant characteristics) and measured soil profile moisture/potential data to predict the ET cover hydrologic performance;
- The ET cover maintenance requirements and effectiveness of maintenance procedures;
- The condition of the ET cover vegetation and trends in the plant community over time;
- The availability of plant nutrients in the soil; and
- Additional information based on technological advances and research related to the performance, monitoring, and maintenance of ET covers.

The following paragraphs briefly describe the anticipated approach to the phased performance monitoring program.

5.2.4.1 Phase I Performance Monitoring

Phase I hydrologic monitoring will begin following application of the permanent seed mixture and will continue for a 6-year period. During the first year of monitoring, which includes the first growing season following the planting of the permanent seed, data will be collected from the monitors on a quarterly basis. Monthly monitoring will begin during the second growing season of the vegetative cover. The hydrologic monitoring will be evaluated after 6 years to evaluate future monitoring requirements. The evaluation will be based on a review of monitoring data collected during the monitoring period, which will include site soil moisture data, vegetation assessment data, and site weather data.

The performance criteria for the ET cover will be based on an assessment of the following parameters:

- Comparison of the ET cover soil water storage (based on soil profile water contents) with the field water storage capacity of the soils;
- Determination of upward or downward hydraulic gradients in ET cover soils (based on the hydraulic potential readings and calculation of water flux rates through the cover based on the hydraulic gradients and soil hydraulic conductivities); and
- Direct measurement of the drainage rate through the lysimeters.

These criteria will be refined after cover installation and initial monitoring, when data variability associated with the site monitoring systems and environmental conditions are better understood. Although monitoring will be conducted on a monthly or quarterly basis, the hydrologic data will be evaluated with respect to the performance assessment criteria on an annual basis. Annual evaluation of the hydrologic data will allow for evaluation of the data with respect to spatial variability (i.e., variability between monitoring locations), seasonal variability (i.e., variability in monitoring results for the active growing season versus the dormant season), and annual variability (i.e., variability between monitoring results for a monitoring period from the current year versus the results for the same monitoring period in previous years). The annual evaluation will therefore allow for a determination of whether or not the performance assessment criteria have been exceeded, as well as an assessment of the potential causes and significance of the unsatisfactory performance, and the most appropriate corrective measures, if applicable. The evaluation will also consider whether an exceedance of the performance assessment criteria was a one-time occurrence or was repeated in more than one monitoring period.

If the monitoring results indicate an exceedance of the performance assessment criteria, additional monitoring and maintenance activities will be conducted. If the exceedance persists or is corroborated by the other monitoring systems, appropriate corrective measures will be evaluated and implemented as necessary to ensure proper functioning of the ET cover.

Standard maintenance activities will be conducted, such as repairs to eroded areas and maintenance of surface water controls, as described in Section 5.2.5.

5.2.4.2 Phase II Performance Monitoring

During Phase II, cover performance will continue to be monitored by observing the appearance of the vegetation. It is anticipated that a correlation may be able to be developed between vegetative cover quality and performance of the ET cover based on the Phase I monitoring results. The results of the Phase I monitoring will be used to develop the Phase II monitoring program, including required frequencies for cover and vegetation inspections, as well as frequencies for hydrologic cover performance monitoring, if appropriate. Standard maintenance activities will continue, as described in Section 5.2.5.

5.2.4.3 Phase III Performance Monitoring

Phase III will focus on the appearance of the ET cover vegetation. Vegetation quality will be monitored and areas with insufficient coverage revegetated. In addition, if deemed necessary, soil nutrients will be applied to the ground surface to promote and aid plant growth. The frequency of inspections and any other required monitoring for Phase III will be determined based on the results of the Phase II monitoring and maintenance program. Standard maintenance activities will continue, as described in Section 5.2.5.

5.2.5 Inspection and Maintenance

The ET cover will be inspected monthly and after periods of significant precipitation⁶, for the first two years. It is anticipated that these inspections can be reduced to quarterly (and after periods of significant precipitation) thereafter. Problem areas will be noted on the inspection record form, graphically depicted, photographed, and repaired, as necessary. At a minimum, the ET cover will be inspected for signs of erosion, weeds, settlement, subsidence, burrowing animals, and seepage areas. Signs of potential problems include, but are not limited to, weed infestations, ponding water on the surface, gully along drainage channels or berms, and surface depressions. The vegetation will be monitored for signs of stress, as dead vegetation may be indicative of problems with the cover system.

⁶ Significant precipitation is defined as 2.5 inches in a 24-hour period (two-year, 24-hour storm)

The plant species and composition of the ET cover vegetation will be monitored to assess the establishment of the grass species and changes in the plant community over time. The composition of the ET cover vegetation is dynamic and dependent on continuously changing environmental conditions. Monitoring of the plant community over time is necessary to define existing plant composition and plant composition trends for the development of a future plant management and maintenance plan.

Routine maintenance of the ET cover will include filling in and re-grading any depressions, burrowing animal holes, or other disturbances. Where excessive erosion has occurred,⁷ soils will be replaced with approved ET cover soils and steps will be taken to prevent further erosion, such as placement of erosion control measures. The work will be performed in a manner that limits significant degradation of the existing cover vegetation. Hand tools and operated equipment will be evaluated for use depending upon the size of the affected area. Following placement of ET cover soils, the eroded area will be re-seeded with the approved seed mix in accordance with the final design specifications and monitored to assess repair. Eroded areas or areas with poor vegetative cover (i.e., areas with less than 50 percent plant coverage) will be re-seeded, as needed.

After restoration of cover soils, the area prone to excessive erosion will be protected further with structural erosion controls such as erosion mats, silt fences, straw bale sediment barriers, and straw bale check dams. These controls will be installed and maintained as necessary to limit sediment transport. The following criteria will be used to determine the proper level of erosion protection:

- If the erosion-prone area previously had only mulch as erosion control measures - implement erosion control measures in accordance with the final design specifications.
- If the erosion prone area previously had only best management practices as erosion control - install a two-year erosion mat.
- If the erosion prone area previously had only temporary erosion mat as erosion control - install a permanent erosion mat in accordance with the final design specifications.

The ET cover will be revegetated as required to maintain the vitality of the vegetative cover based on visual inspection. The progress of the cover vegetation will be assessed each year. Areas with poor coverage (<50 percent plant coverage), bare spots, and eroded areas will be evaluated to assess soil productivity and reworked, fertilized, re-seeded with the original seed mixture in accordance with the final design specifications, and mulched. Areas that exhibit repeated excessive erosion may require implementation of erosion control measures to allow for establishment of vegetation.

To promote the establishment of a native grass community, herbicide applications mowing, and/or prescribed burns may be necessary to reduce the development of undesirable plants. It is anticipated that localized mowing with a trimmer and spot herbicide application will be the first line of defense against weed infestation. The long-term weed control measures will be evaluated upon completion of Phase I monitoring assessments.

A walking inspection of the surface water controls will be performed on a monthly basis and after periods of significant precipitation for the first two growing seasons to help develop the maintenance program. It is anticipated the frequency of inspections may be reduced to quarterly (and after periods of significant precipitation) thereafter. Problem areas will be noted on the inspection record, graphically depicted, photographed, and repaired, if necessary. At a minimum, these structures will be inspected for signs of excessive erosion, settlement, bank failure, breaching of diversion berms, subsidence, burrowing animals, and blockage. Signs of potential problems include, but are not limited to, ponding water, gullying, sediment build-up, and depressions in the cover surface.

⁷ Excessive erosion is defined as soil loss in substantial excess (i.e., more than 2 inches of soil loss as determined by visual inspection) over adjacent areas with good stands of vegetation or rills or gullies deeper than 6 inches.

52

Routine maintenance of the surface water controls will include removing any blockages, filling eroded areas and burrowing animal holes, repairing or replacing silt fences and straw bales, and repairing other disturbances as necessary. Areas that exhibit excessive erosion may require placement of erosion control devices. Sedimentation may build up in areas of the surface water controls. Periodically, sediments will be removed to restore the design characteristics of the surface water control structure.

Inspection and maintenance activities will be documented in a performance report, as described in Section 5.3. This documentation will include a map showing the locations of all cover, drainage, and vegetation restoration activities conducted since installation of the ET cover.

5.2.6 Additional Monitoring and Evaluation Activities

Additional monitoring and evaluation activities may be conducted based on the performance assessment described in Section 5.3. These may include, but need not be limited to, the following actions:

- Increase monitoring and maintenance frequency from quarterly to monthly, or extend into the future, as applicable.
- Install additional monitoring points around the monitoring location(s) where assessment criteria have been exceeded to further define the extent of any potential deficiencies.
- Conduct additional monitoring to assess vegetation cover and soil productivity, and determine if any deficiencies require corrective measure(s).
- Perform additional UNSAT-H modeling following model calibration using measured soil water data.
- Conduct a ground survey to verify positive drainage from the ET cover surface. The survey will provide sufficient detail to produce a topographic map of the ET cover surface. The map will be used to compare the existing surface with as-built topography generated from construction record survey data. If significant changes in surface grade or the surface water drainage path are indicated, the surface water drainage design will be re-evaluated using the same methods as those used in the original design.
- If the measured soil water coveracity exceeds the field water storage coveracity⁸, calibrate the neutron probes and verify they are functioning properly.
- If the water flux estimate indicates substantial downward drainage through the cover, calibrate the monitoring equipment and verify it is functioning properly.
- If the measured lysimeter drainage rate exceeds 1 cm/year, verify the lysimeters are functioning properly.

⁸ The field coveracity is the amount of water stored in a saturated soil after excess water has drained out of the soil through gravity and the downward drainage of water from the soil column is negligible. The movement of water upward or downward in soil is a dynamic process, therefore, the field coveracity is not a constant value but a gross estimate of the coveracity of the soil column to store or maintain water. Soil water in excess of the field coveracity indicates the potential for significant downward drainage through the soil column, while soil water measured at less than the field coveracity indicates that significant downward drainage through the soil column is unlikely.

53

5.3 Performance Assessment & Reporting

For each 12-month monitoring period following installation of the Present Landfill cover, a report will be prepared to provide an evaluation of the hydrologic performance of the Present Landfill cover, an assessment of the ET cover vegetation, and information necessary to support future corrective measures, if necessary. The report will be based on an evaluation of the following monitoring data:

- Monitoring station soil characteristics,
- Site precipitation data and pertinent climatic data,
- Soil water contents within ET cover soil profiles,
- Soil water storage within lysimeters and the ET cover,
- Hydraulic potentials within ET cover soil profiles,
- Predicted seasonal and annual soil water flux rates within the ET cover,
- Measured drainage from lysimeters,
- Suitability of the monitoring systems to define ET cover hydrologic performance based on site conditions, and
- Condition of the ET cover vegetation

The report will summarize the data and provide evaluations and/or interpretations for observed ET cover hydrologic response to variations in climatic conditions, vegetation, soil condition, and monitoring locations. If ET cover performance is determined to be unsatisfactory, appropriate corrective measures will be specified in the report. In addition, the report will summarize all monitoring and repair activities completed within the last year.

5.4 Corrective Measures

Corrective measures will be implemented if the results of the periodic performance assessments indicate that the ET cover is not functioning properly. Corrective measures that may be implemented include the following:

- Increase erosion controls where necessary.
- Re-grade the ET cover surface to address surface water drainage problems.
- Improve existing surface water controls or construct of additional surface water controls.
- Enhance soil productivity through addition of soil amendments to improve vitality of plant growth.
- Re-seed of portions of the ET cover to improve vitality of plant growth.

Proposed corrective measures will be discussed with EPA and CDPHE before implementation. Following implementation of a corrective measure, performance monitoring will be conducted for two additional growing seasons to allow for improved vitality of the ET cover vegetation. If satisfactory results are obtained, monitoring will be continued as specified in the Phase I monitoring program for one growing season following demonstration that the ET cover performance assessment criteria are being met. If unsatisfactory performance persists, additional evaluations will be conducted and additional corrective measures and monitoring proposed and implemented as necessary to demonstrate that corrective measures are effective in achieving the ET cover performance assessment criteria.

54

5.5 CERCLA Five-Year Reviews

Under 121(c) of CERCLA and Section 300.430(f)(4)(ii) of the National Contingency Plan (NCP), statutory reviews are required at least every 5 years to ensure the remedial action remains protective of human health and the environment. The level of the reviews will be at the discretion of EPA and CPDHE; however, it is expected that a Level I review, consisting of a site visit, review of operation and maintenance activities, and a brief site

inspection will be sufficient. These reviews will evaluate the performance of the Present Landfill cover based on the groundwater monitoring, gas vent monitoring, surface water monitoring, hydrologic cover performance monitoring, inspection, and maintenance activities conducted during the review period.

6.0 ENVIRONMENTAL CONSEQUENCES

¶95 of RFCA mandates incorporation of NEPA values into RFETS decision documents. This section of the IM/IRA satisfies the RFCA requirement for a “NEPA equivalency” assessment of environmental consequences by addressing the environmental consequences of the proposed action. The analysis incorporates several previously completed documents and generally accepted assumptions to evaluate impacts in specific resource areas. Offsite transportation impacts from implementing offsite treatment and disposal alternatives are addressed in Attachment 3 to the RSOP for Facility Disposition (DOE 2000b) and in the CID (DOE 1997) and 2000 CID Update Report (DOE 2001a). Offsite facilities considered for waste disposal (i.e., sanitary waste) are assumed to be in operation, to be properly licensed and permitted to provide such services, and to have sufficient capacity to handle the waste. Specific locations of local soil/borrow facilities to be used for the proposed action have not yet been identified.

The remediation impact analysis relies heavily on conclusions reached in the CID (DOE 1997) and 2000 CID Update Report (DOE 2001a), both of which focus on cumulative impacts resulting from onsite closure activities. In general, the proposed action will result in adverse short-term impacts in a variety of resource areas, including air quality, water quality, traffic congestion, and ecological resources. In many instances, the impacts could be intense for a short period of time. However, the impacts will not notably affect human health and safety, or the environment, and they will be temporary and controlled through mitigation actions (e.g., dust will be controlled with water sprays during placement of the ET cover).

6.1 Impacts to Air Quality

The purpose of this section is to assess the potential impacts to air quality associated with the proposed installation and maintenance of the ET cover, including fugitive dust emissions and methane emissions.

6.1.1 Potential Fugitive Dust Emissions

The primary pollutant generated as a result of the proposed action will be fugitive dust, which includes TSP and PM_{10} , and particulate matter 2.5 microns ($PM_{2.5}$) in size. Dust emissions from cover construction activities will be controlled with practical, economically reasonable, and technologically feasible work practices, as required by the CAQCC Regulation No. 1. Specifically, onsite dust will be controlled through dust minimization techniques, such as the use of water sprays to minimize suspension of particulates, and stopping earthmoving operations during periods of high wind. In addition, TSP and PM_{10} (as well as other criteria pollutants) will be monitored consistent with the Site IMP (DOE 2000a) to ensure air emissions remain within acceptable levels. Opacity rules, limiting opacity below a 20-percent standard, will also be followed. Particulate emissions will be short-term and controllable, and emissions are not expected to be above enforceable National Ambient Air Quality Standards (NAAQSs) at the RFETS perimeter. In addition, RFETS air quality staff calculate project emissions on an ongoing basis to determine additional regulatory reporting requirements. Therefore, potential impacts to workers and the public from proposed action will not be significant.

ET cover construction activities will also include operation of vehicles, heavy machinery, and other equipment that generate other criteria pollutants. Estimated concentrations of other criteria and HAPs provided in the CID (DOE 1997) were well below the most restrictive occupational exposure limit, with the exceptions of sulfur dioxide, nitrogen dioxide, and CO, which approached 50 percent of the most restrictive occupational exposure limit. The CID (DOE 1997) identified the primary sources of these pollutants as diesel-powered emergency generators used to supply backup power at RFETS. According to the 2000 CID Update Report (DOE 2001a), maximum daily emissions will remain about the same as forecast in the CID (DOE 1997). Equipment emissions from remediation activities are expected to be

substantially less than the CID (DOE 1997) and 2000 CID Update Report (DOE 2001a) estimates; therefore, impacts to workers and the public are not a concern in this IM/IRA. In addition, temporary fossil-fuel-fired equipment use and fuel use will be tracked to ensure that emissions remain within the regulatory limits, or that appropriate notices or permit modifications are filed.

6.1.2 Potential Methane Emissions

Methane emissions from the Present Landfill have been estimated as described in Section 2.9. EPA's LANDGEM model was used to estimate total landfill gas emissions by estimating methane, carbon dioxide, and NMOC emissions individually, and then summing the three results. The model indicated relatively low rates of landfill gas generation (approximately 30,000,000 ft³/yr total gas; 163,460,000 ft³/yr methane), with the majority (approximately 80 percent) of methane and total landfill gas production occurring by the year 2025, and almost all potential production by the year 2075.

6.2 Impacts to Surface Water

Construction activities associated with installation of the ET cover will result in surface disturbance from the clearing of vegetation, excavation and salvage of topsoil material, blading and leveling of land preceding construction, and the potential for accidental uncovering of contaminated media. Potential impacts to surface water during the construction phase include increased erosion, and subsequent sediment loading to drainage ditches and No Name Gulch during storm events. The absence of vegetative cover and the steepening of slopes result in increased potential for both sheet and channelized run-off, and wind and water erosion, resulting in increased sedimentation of ditches and No Name Gulch.

The proposed action is limited to constructing an ET cover system for containment of the landfill waste, removal of the East Landfill Pond dam, and the excavation and placement in the landfill of the pond sediments. Construction requires soil obtained from offsite commercial operations. Excavation of these borrow materials has impacts similar to those identified above, which are addressed in permits issued for the offsite facilities. The proposed construction activities are not expected to have any physical contact with contaminated soils or waste materials. In the event equipment and personnel come in contact with potentially contaminated materials during construction, decontamination will be performed at the RFETS main decontamination facility to reduce potential impacts to surface water.

Given the expected conditions, no significant surface water impacts are expected. However, because the total area of the project is greater than 5 acres and the location is outside the IA, which has an effective NPDES Permit for Storm Water, the proposed action would require an NPDES Storm Water Permit for Construction Activities, but for the fact that it is a CERCLA action. Paragraphs 16 and 17 of RFCA establish the requirements under which CERCLA permit waiver applies. For any action that would require a permit but for CERCLA, Paragraph 17 requires that the following information be included in the submittal:

- a. Identification of each permit that would be required – Because this construction project is greater than 5 acres in size, an NPDES General Storm Water Permit for Construction Activities would be required. The permit is found at 40 CFR 122, and is obtained by filing a Notification of Intent (NOI) with EPA.
- b. Identification of the standards, requirements, criteria, or limitation that would have had to have been met to obtain each permit – Because the storm water permit for construction activities is a general permit, it has been through public comment and promulgated by EPA. Obtaining the permit is through the NOI, a letter submittal to the agency containing basic information about the project, all of which is contained within this IM/IRA. The permit requires the installation of best management practices, such as silt fences, to protect downstream waters from sediment-laden run-off.

- c. Explanation of how the proposed action will meet the standards, requirements, criteria, or limitations identified in subparagraph (b) – The total area of disturbed soils is approximately 41 acres, including the area of the landfill to be resurfaced (28 acres), haul roads to the offsite borrow areas (9 acres), and miscellaneous construction activities (2 acres). Surface water control measures will be used to minimize surface water contact with potentially contaminated soils or groundwater and to minimize erosional effects during the construction activities. Precipitation falling on areas where construction is in progress will be diverted to existing surface water drainage ditches. Other shallow ditches will be temporarily constructed as needed to prevent sediment-laden storm water from flowing directly into No Name Gulch.

Newly-constructed soil surfaces will be protected using soil terracing, hydromulch, straw-mulch, silt fencing or other appropriate method to minimize soil erosion and surface water degradation until the required vegetation is established. Average potential loss of soils from newly-constructed surfaces due to water erosion is estimated at 6 tons/acre/year for the first two years during and after construction activities. This loss has been estimated using the universal soil loss equation (USLE). The use of straw-mulch, adequately spaced silt fences, and other appropriate measures minimizes soil loss and allows the final vegetative cover to be established within two to three years. Potential soil loss from surfaces with established vegetation similar to surrounding areas is estimated at 0.5 tons/acre/year.

Long-term impacts will be minimized because the ET cover will minimize infiltration of precipitation and subsequent contact with contaminants, and it will incorporate surface drainage features to prevent run-on/run-off and to provide erosion control. The proposed action will result in a decrease in the risk of contaminants reaching surface water by eliminating the possibility of precipitation contacting contaminated soils or waste materials. Precipitation falling within the boundary of the landfill will be drained from the cover and diverted away from the landfill. Surface water drainage from areas outside the landfill boundary would be prevented from flowing onto the landfill and diverted around the boundary. Using appropriate surface-reclamation measures, adequate vegetative cover will be established on the final surface of the landfill in two to three years. The establishment of vegetative cover on stabilized slopes, contours of the landfill, and the surrounding disturbed surfaces will greatly reduce erosional hazards to levels similar to surrounding areas.

Post-closure monitoring activities will include inspections of the landfill surface and associated drainage ditch conditions. Observations of the vegetative cover and evidence of soil erosion and loss will be included in the routine inspection and maintenance activities. Further erosion control measures, re-grading, and revegetation will be implemented if maintenance inspections indicate the landfill surface reclamation is not effective as planned.

6.3 Impacts to Groundwater

Current sources of groundwater recharge to the UHSU include infiltration of precipitation, snowmelt, storm water run-off, and downward seepage from the East Landfill Pond. The downward seepage from the East Landfill Pond will be eliminated with the removal of the pond. The level of groundwater rises annually in response to spring and summer recharge and declines during the remainder of the year. Groundwater generally flows to the east; however, localized flow follows topographic slopes toward the pond or toward the drainage below the dam. Groundwater intermittently flows to the east within the saturated valley-fill alluvium. The average depth to groundwater in the landfill mass is approximately 20 feet; the average saturated thickness is 11 feet.

Local impacts to hydraulic gradients are expected because the ET cover will reduce surface water infiltration. However, enhanced groundwater quality will result from reducing water flow through waste. The ET cover will cause an increase in surface water flows after storm events as water is shed laterally, rather than infiltrating the surface. The surface water drainage ditch will divert storm water run-off around the landfill, resulting in further reduction of surface infiltration and groundwater recharge through waste material.

The long-term effects of constructing the low-permeability cover will be almost 100 percent reduction of precipitation reaching the waste. This would cause a significant reduction in saturated thickness of the waste material and eliminate much of the seasonal variability of leachate flow rates. A significant reduction of saturated waste and elimination of vertical infiltration flows through waste above the water table would result in reduced leachate generation and migration, which would ultimately reduce contaminant loading to groundwater.

The overall impact to groundwater from the proposed action will be enhanced groundwater quality at the site. No significant negative impact to groundwater quality is expected from the proposed action.

6.4 Impacts to Wildlife & Vegetation

Cover construction activities at the Present Landfill may result in temporary effects on vegetation communities and wildlife habitat in and around the remediated areas. Temporary effects due to surface disturbance associated with cover construction and noise associated with heavy equipment are expected.

Approximately 39 acres will be affected by construction activities, which will include resurfacing the landfill (28 acres), constructing the borrow-area haul road (9 acres), and miscellaneous activities, including the construction of staging areas (2 acres). Borrow area and staging area sites are located in mid-grass prairie vegetation communities and currently contain a mixture of native and non-native plants.

Detailed revegetation plans for each of these areas will be included in the final design documents. Revegetation of areas outside the ET cover will include native prairie species. Because of the need to control soil erosion, the ET cover will be revegetated with sod-forming grasses that provide optimal basal cover at maturity. Where possible, native grasses such as Canada bluegrass, blue grama, or side-oats grama will be used. To avoid root penetration of the clay cap, measures will be taken to prevent woody species such as shrubs and trees or other deep-rooted phreatophytic species from becoming established on the cover. Thus, the ET cover will be revegetated but will not be restored to the native mid-grass prairie condition that existed prior to landfill construction. The initial establishment of herbaceous vegetation is expected to take two to three years. Establishment of woody species and slower-growing perennials may take up to 10 years.

The period of increased equipment noise, vehicular traffic, and other human activity will last less than one year. During this time, sensitive wildlife species may avoid the area. The area affected is highly variable and dependent on species and individuals. Some animals may habituate to the activity and return to the area. Although wildlife use of the area may be reduced because of this avoidance response, this part of Walnut Creek drainage does not represent critical habitat or breeding areas for site wildlife.

Long-term impacts on ecological resources will include physical alteration of terrestrial and aquatic habitats and residual chemical risks in areas adjacent to the landfill, outside the ET cover. Physical alteration of the habitats will include degradation and/or permanent loss of existing habitat. The primary areas involved are mid-grass prairie in the borrow and staging sites, the mid-grass prairie immediately surrounding the landfill and the East Landfill Pond, the wetland and aquatic habitats associated with the pond, and the riparian/grassland areas immediately east of the pond.

As noted previously, the potential borrow area and staging area sites represent only temporary loss of habitat since they will be revegetated with native species after completion of the landfill cap. To some extent, the landfill area represents a permanent loss of native mid-grass prairie because revegetation efforts cannot include a completely native plant community. However, the revegetated cap will be suitable habitat for many wildlife species, especially small mammals, some songbirds, and other grassland wildlife species that do not require a structurally complex vegetation community.

Removal of the East Landfill Pond represents permanent loss of the associated aquatic and wetland habitats. A total of 3.1 acres of jurisdictional wetlands will be lost as a result of pond removal. This includes 0.8 acres of palustrine emergent wetlands at the pond margin and 2.3 acres of lacustrine wetland associated with the pond bottom and open-water habitat combined. This 0.8 acres of palustrine wetlands represents about 0.5 percent of the palustrine and riverine wetlands at RFETS. Removal of the East Landfill Pond also represents about a 5 percent reduction in open water habitat and about 6 percent reduction in shoreline habitat. In addition, potential habitat for Preble's meadow jumping mouse will be lost or modified as a result of the pond removal. At RFETS, this mouse is typically associated with riparian communities and the adjacent grassland habitats. Removal of the pond will essentially eliminate the riparian component. Live-trapping surveys of the area have not confirmed the presence of Preble's meadow jumping mouse in the vicinity of the Present Landfill. Thus, risks to Preble's meadow jumping mouse from the proposed action may be limited to loss of potential habitat.

The loss of jurisdictional wetlands due to the proposed action will be mitigated as part of the sitewide wetlands bank. Mitigation of other habitat loss is not required by state or federal statutes and is not currently anticipated. However, DOE may include mitigation of wildlife habitat as part of sitewide conservation management plans to be developed in the future.

6.5 Impacts to Transportation

The proposed action is expected to cause direct and indirect impacts to the transportation systems in and around RFETS. Most materials necessary for the construction of the ET cover will be transported using tandem semi-trucks from a nearby onsite or offsite borrow source, which has not yet been identified.

In the event an onsite borrow source is used for cover material, a haul road will be constructed from the borrow source to the Present Landfill site. The haul road will be paved with aggregate road base only. The new haul road results in no impact to State Highway 93 west of RFETS.

In the event an offsite borrow source is selected, short-term impacts to State Highway will result. Other construction materials and supplies, as well as construction mobilization equipment and construction personnel, will be transported over existing transportation routes. The traffic impacts from these activities are expected to be minor.

6.6 Impacts to Cultural & Historic Resources

The Rocky Flats Plant site was placed on the National Register of Historic Places as a Historic District (5JF1227) on May 19, 1997. Historic District designation mandates compliance with the Historic Preservation Act of 1966, and the Programmatic Agreement among DOE, the Colorado State Historic Preservation Officer, and the Advisory Council on Historic Preservation Regarding Historic Properties at RFETS. While the Reduced Infiltration/Wetlands Treatment project site would be within the Historic District boundaries, no impact is expected to occur to protected structures. In the unlikely event that potentially historic artifacts are encountered, appropriate Site procedures will be followed.

60

6.7 Impacts to Visual Resources

During installation of the ET cover, bulldozers and other equipment may be visible from offsite locations. Dust generated during earth-moving operations may be temporarily visible, but will dissipate before leaving the Site as a visible cloud or plume of dust. Control measures, such as watering, will be used if needed to control dust.

6.8 Noise Impacts

Noise levels may be elevated during construction of the ET cover. Noise levels will not exceed those commonly encountered at a highway construction site. Appropriate hearing protection will be supplied to project personnel as identified in the project-specific HASP.

6.9 Cumulative Impacts

The proposed action supports the overall mission to clean up RFETS and make it safe for future uses. The cumulative effects of this broad, sitewide effort are presented in the CID (DOE 1997) and 2000 CID Update Report (DOE 2001a), which describe the short-term and long-term effects from the overall cleanup mission.

The primary focus of the CID (DOE 1997) was on cumulative impacts resulting from onsite activities conducted during Site closure. Cumulative impacts result from the effects of Site closure activities and other actions taken during the same time in the same geographic area, including offsite activities, regardless of what agency or person undertakes such other action. The analysis contained in the 2000 CID Update Report (DOE 2001a) included updated onsite and offsite transportation activities, as well as several new offsite activities, although the future non-DOE projects are relatively uncertain. Increased traffic congestion will be the most noticeable impact according to the 2000 CID Update Report (DOE 2001a), resulting from increased RFETS traffic and other planned or proposed construction projects near RFETS. Air pollutants and noise will also have adverse impacts; however, the impacts are expected to be short-term in nature, with staggered project start and completion dates. Most people will perceive a positive, long-term visual and “quality of life” benefit, as RFETS infrastructure and equipment are removed, returning RFETS to a more natural appearance.

The cumulative impacts of the proposed action are expected to be similar to those analyzed in the CID (DOE 1997) and 2000 CID Update Report (DOE 2001a). Over the short term, additional construction personnel will have an additive effect on the existing workload for Site operations, and there will be increased air emissions, visual impacts, noise, and traffic impacts resulting from construction activities. These short-term impacts will be substantial. Long-term impacts (i.e., Present Landfill cover construction activities in conjunction with other ER work and facility decommissioning activities) facilitate future use of the Site and fulfill the mandated cleanup objectives.

6.10 Irreversible & Irretrievable Commitment of Resources

The proposed action will result in a variety of permanent commitments of resources but it is not expected to result in a substantial loss of valuable resources. Most of the resources used for construction of the ET cover are permanently committed to implementation of the remedial action. Irreversible and irretrievable resources are defined as resources that are either consumed, committed, or lost. At the Present Landfill, irreversible and irretrievable resources include the following:

- Consumptive use of geological resources (e.g., quarried rock, clay, sand, and gravel for road construction) will be required for construction activities. Supplies of these materials will be

61

provided by an onsite, offsite, or offsite commercial borrow source. The proposed action requires a permanent commitment of approximately 234,000 yd³ of fill, topsoil, and vegetative cover from to construct the Present Landfill cover. However, adequate supplies are available without affecting local demand for these products.

- Fuel consumed by construction equipment and vehicles used for the construction of the Present Landfill cover will not be recovered.
- Soils in the vicinity of the Present Landfill will be disturbed by construction activities. Many impacts are temporary, pending completion of remedial activities and associated restoration programs.
- Resources that underlie the landfill will be lost. However, there appear to be no commercially exploitable mineral resources at RFETS.
- The commitment of up to 30 acres of land as a landfill permanently commits and constrains the area to limited land-use options.
- Wetlands and associated natural resources will be reduced at the Present Landfill but will be mitigated offsite. Long-term direct impacts to the floodplain resulting in changes of flood elevations will not occur.
- Open water habitat at the Present Landfill will be eliminated. This loss represents about 5 percent of the open water habitat at RFETS.
- Long-term commitment of personnel and funds to perform post-closure inspection, maintenance, and monitoring activities.
- Maintenance activities will be performed as necessary. Long-term negative environmental impacts are not expected to occur from the Present Landfill selected remedy. Monitoring and periodic site inspections would be performed to ensure long-term protection of human health and the environment.

Commercial, industrial, and residential land uses are permanently prohibited within boundaries of the Present Landfill due to construction of the ET cover and the network of monitoring wells. Appropriate landfill surface reclamation results in an acceptable appearance of the remediated site, and the ecological succession of the closed landfill and adjacent land are improved by surface revegetation. Vegetation and habitat eventually become similar to surrounding areas.

Incidental resources that are consumed, committed, or lost on a temporary and/or partial basis during construction include construction personnel and equipment, the construction water source, and the construction materials used for equipment haul roads. During construction of the ET cover, it is expected that 20 to 35 personnel will be required for the duration of the construction activities (less than 1 year). The raw water supply available at RFETS will be used to conserve water that is treated by the onsite water treatment plant. The compacted soil portion of the ET cover system would require 8 to 10 million gallons of water during construction activities. Approximately 7,000 to 8,000 yd³ of material will be used temporarily for construction of haul roads.

62

7.0 LONG-TERM STEWARDSHIP

The objective of this section is to identify and organize the components of a long-term stewardship program at RFETS. Much of the information contained in this section has been presented in greater detail elsewhere in the document. This information is being repeated here to provide for a complete analysis of how long-term stewardship will be integrated into the Present Landfill project. Since the presumptive remedy for a landfill is an ET cover, a traditional stewardship evaluation was not completed during remedy selection. That is, the long-term stewardship implications of various types of remedies were not compared with one another.

Important long-term stewardship components include engineered controls, institutional controls, operational and performance monitoring and maintenance, information management, periodic assessment, and maintenance by a responsible controlling authority. This section evaluates the interim action of cover installation and seep treatment, and it outlines the minimum stewardship considerations, which will be finalized in the Corrective Action Decision/Record of Decision (CAD/ROD). Ultimately, DOE will be responsible for implementing and maintaining the long-term stewardship components of this remedy.

The ET cover has been assessed in accordance with the methodology presented in the Rocky Flats Stewardship Toolbox (Rocky Flats Stewardship Working Group, 2002) and Long-Term Stewardship Study, Volume I-Report (DOE 2001c). The Site Draft Long-Term Stewardship Strategy, currently a draft document in preparation by DOE, was also consulted in the preparation of this analysis.

The purpose of the ET cover is to prevent infiltration of precipitation to minimize leachate production and potential impacts to human health and the environment. The cover will be constructed primarily of natural materials and will be designed to maximize design life and minimize operations and maintenance requirements. Once the vegetation is established, maintenance will be minimal. A phased monitoring program will be implemented to provide for more intensive monitoring in the early years, until the cover is proven effective. As system performance is demonstrated, monitoring will be decreased and, based on results, may be eliminated over the long term.

7.1 Engineered Controls

Engineered controls are the primary barriers used to limit exposure to hazards that exist on the site after remediation is complete, and to limit the migration or mobility of residual contamination. Engineered controls include, but are not limited to, containment structures such as covers, and water diversion and treatment systems. These controls physically reside at the site of, or in close proximity to, the actual contamination. The primary engineered control associated with the proposed remedy is the cover. The objective of the cover is to:

- Protect surface water per RFCA,
- Close the RCRA interim status unit and meet CERCLA requirements (the presumptive remedy for landfills is a cap or cover),
- Minimize adverse impacts associated with the closure/accelerated action, and
- Create a stable configuration consistent with the anticipated wildlife refuge future use.

In addition to the cover, the passive seep treatment system will be rebuilt on the east slope of the Present Landfill to treat the seep before the water enters No Name Gulch. Engineered controls installed as part of previous remedial actions include the GWIS and the groundwater slurry walls on the north and south sides of the Present Landfill.

7.2 Institutional Controls

Institutional controls include governmental controls such as zoning, permits, and use restrictions; proprietary controls such as easements and covenants; legal enforcement tools such as administrative orders and consent decrees; and informational devices such as deed notices, registries and advisories. Physical controls, such as fences, guards, and gates that restrict access to the site, are included here as a subset of institutional controls.

The Rocky Flats Wildlife Refuge Act of 2001 will serve as the primary institutional control for the Site, ensuring continued Federal ownership and establishing DOE administrative jurisdiction for the remedy. In addition, this IM/IRA and the Monitoring and Maintenance Plan that will be developed prior to completing the construction of the ET cover contain administrative controls and commitments associated with the ET cover. Since the Present Landfill will remain under federal ownership, traditional governmental and informational devices, such as deed restrictions, are not applicable. However, the landfill surface will not be suitable for development, and the cover should not be subjected to deep digging or drilling activities that are not associated with the maintenance or repair of the cover itself or the installation of additional remedies. These considerations will need to be factored into the long-term management of the Site following closure.

Site security and access controls will be maintained until completion of the RFETS Closure Project, currently scheduled for December 2006. Access deterrents will not be required for the success of the ET cover; however, access deterrents may be installed to ensure optimal long-term performance of the remedy. For example, foot traffic will not damage the cover, but prolonged foot traffic or vehicular traffic could affect the vegetation, which would influence the cover performance. In order to avoid this impact, a fence could be erected around the landfill, established trails should be prohibited from the cover itself, and/or signs could be erected that indicate vehicles are prohibited from the surface.

Fencing around monitoring locations will also be considered to limit the potential for damage or tampering with the location. Once the final design is complete, the monitoring equipment and data management system will be re-assessed to determine whether fencing is required. Signs and markers may be effective passive controls. The signs could outline digging restrictions; cover, monitoring location, and seep treatment system access restrictions; and delineate the landfill boundary.

7.3 Monitoring & Maintenance

Remedies and corresponding stewardship controls, whether physical or institutional, require periodic monitoring and maintenance to ensure they continue to work as designed. The objective of monitoring and maintenance is to ensure that the remedy remains effective until it is no longer needed or a better remedy is developed and implemented.

After cover installation, there will be operational and performance monitoring. Operational monitoring will involve groundwater, gas venting, and surface water monitors. The objective of operational monitoring is to assess the cover's effectiveness at minimizing the landfill's impacts to the surrounding environment. Operation monitors will be at the unit boundary (i.e., waste placement boundary). Operational monitoring will be conducted until it can be demonstrated that the landfill no longer poses a risk to surface water. The operational monitoring will be conducted in accordance with the Site IMP (DOE 2000a) methodology and reported in quarterly and annual reports. Once the CAD/ROD is complete, the operational monitoring will be conducted and reported in accordance with that methodology. Section 5.2 addresses the post-closure monitoring, maintenance, and inspections associated with the Present Landfill cover.

Performance monitoring will involve monitors installed within the cover to evaluate the infiltration rate of precipitation through the cover. Section 5.2 addresses the post-closure monitoring, maintenance, and inspections associated with the Present Landfill cover. Performance monitoring results will be evaluated with inspection criteria. If the inspections and performance monitoring indicate that a single location within the landfill is failing (e.g., excessive erosion, poor vegetation), then the condition will be repaired. A Monitoring and Maintenance Manual will be prepared before completing the cover construction. At a minimum, the manual will include the following elements:

- Irrigation and fertilization of the cover vegetation past the warranty period,
- Inspection and maintenance of the storm water management system,
- Inspection and maintenance of the ET cover, and
- Monitoring system support and maintenance.

In addition, this plan will describe the phases of monitoring and the decision/performance criteria that will be used to transition from one phase to the next. The manual will be of sufficient detail to ensure that the user of the manual does not need to be familiar with the cover final design documents.

Inspections will be completed on a routine basis. At a minimum, the inspections will include the condition of the following:

- Access controls and signs;
- Landfill surface for settlement, cracks, erosion, holes, vegetative cover, alternative cover, bulges, wet areas, and slope instability;
- Gas vents;
- Performance monitoring stations;
- Groundwater monitoring wells;
- Surface water monitoring locations;
- Seep treatment system; and
- Storm water channels for siltation, vegetative growth, and erosion.

Maintenance will be based on inspections but routine maintenance is projected to consist of cleaning out debris from the seep treatment system and storm water channels, repair of the cover surface from burrowing animals, and vegetation management.

7.4 Information Management

A successful stewardship program is dependent on retaining all necessary records about the history and residual contamination of the site. Information that must be retained should include history of the site, the contaminants of concern, the selected remedies, the use of controls along with their monitoring and maintenance records, and any other information judged necessary for succeeding generations to understand the nature and extent of the residual contamination. At a minimum, the following records will be retained, stored, and retrievable for this accelerated action:

- This IM/IRA and any future modifications,
- The final 100 percent design for the ET cover and field change requests,
- The as-built drawings of the ET cover,

- Monitoring and maintenance manual and subsequent revisions,
- Inspection records and logbooks,
- Maintenance records and logbooks,
- Annual performance assessment reports,
- CERCLA 5-Year Review reports,
- Correspondence between the agencies associated with monitoring modifications,
- Memorandum of Understanding (MOU) between DOE and DOI (identify controlling authority),
- CAD/ROD, and
- The RFETS Historical Release Report (HRR) and other relevant historical documentation.

This information will be maintained in the CERCLA Administrative Record File or the post-decision Administrative Record File. Currently, the Administrative Record file is maintained on-site. It is anticipated that after closure, the Administrative Record may be maintained at the Federal Center in Lakewood, Colorado or some other federal record center. DOE is currently looking at options for retention of permanent records following Site closure.

7.5 Periodic Assessments

Periodic assessments are performed to determine whether the selected remedies and stewardship controls continue to operate as designed, and to ascertain whether new technologies might exist to eliminate remaining residual contamination in a safe and cost-effective manner. The CERCLA five-year review process is required for all Superfund sites that leave residual contamination behind after closure, and will establish the minimum requirements for post-closure periodic assessments. The EPA "Comprehensive Five-Year Review Guidance," dated June 2001, describes the format of the five-year review and suggests mechanisms that can be implemented through the five-year review process to assure the protectiveness of the remedy. DOE is responsible for conducting the five-year reviews and then EPA issues a finding of concurrence or non-concurrence. RCRA also requires periodic assessment.

This periodic assessment will include actions such as evaluating monitoring and maintenance records, looking at how information records are being maintained, verifying regulatory compliance, and determining whether land use assumptions are still valid. An important part of managing the assessment program is to develop and be ready to implement contingencies in case of failed performance of either the remedy or its associated controls.

In addition to the formal periodic assessment, the performance monitoring program will be established in phases. The monitoring program will provide assessment of the cover performance on a more frequent and routine basis. Monthly inspections will be designed to assess the cover performance and landfill impact on the surrounding environment. If these inspections indicate that the cover is not performing or the landfill is impacting surface water, remedial action will be taken. Cover repair and maintenance will be within the scope of the Monitoring and Maintenance Manual. Actions to modify the cover performance or undertake additional remedial actions will require a modification to an existing RFCA decision document, development of a separate RFCA decision document, or amendment to the CAD/ROD.

7.6 Controlling Authority

Long-term protection of human health and the environment necessitates that a controlling authority be established with responsibility for overall stewardship program management and guidance. CERCLA mandates that DOE, as the responsible party, will retain responsibility for the contamination at RFETS resulting from its activities there, as well as responsibility for long-term maintenance of any remedies. The Rocky Flats National Wildlife Act of 2001 requires that, following certification by EPA, certain lands of the current Site will be transferred from the Secretary of Energy to the Secretary of the Interior. These lands would be under administrative jurisdiction of the USFWS. The Act also requires the Secretary of Energy to retain administrative jurisdiction over Site lands required to carry out response actions required for the cleanup and closure of the Site. The MOU currently being negotiated between DOE and DOI will outline this process, although it is unlikely the final boundaries of the land will be determined until the final cleanup and closure plans are approved. However, the Present Landfill will remain under the administrative jurisdiction of the Secretary of Energy.

An overlay refuge may be established in the areas where the Secretary of Energy retains administrative jurisdiction. Although not formally defined, an overlay area would give USFWS law enforcement jurisdiction, including authority to control trespass and arrest and prosecute violators on the overlay property. It is anticipated such an arrangement could be established at the Present Landfill site.

67

8.0 APPLICABLE OR RELEVANT & APPROPRIATE REQUIREMENTS

As required by Part 4 of RFCA, the proposed action will be performed in compliance with ARARs under CERCLA. ARARs have been identified for the proposed action consistent with the NCP, the preambles to the proposed and final NCP, and CERCLA Compliance with Other Laws Manuals Part I and Part II (EPA 1988 and 1989). The ARARs are provided in Appendix B.

8.1 RCRA Unit Closure

The Present Landfill will be closed in accordance with the RCRA closure performance standard for interim status units (6 CCR 1007-3, Part 265.111), which requires DOE to close the unit in a manner that:

- (a) Minimizes the need for further maintenance; and
- (b) Controls, minimizes or eliminates, to the extent necessary to protect human health and the environment, post-closure escape of hazardous waste, hazardous constituents, leachate, contaminated run-off, or hazardous waste decomposition products to groundwater or surface water or to the atmosphere; and
- (c) If the unit is a landfill, complies with the closure and post-closure requirements of Part 265.310.

Part 265.310(a) stipulates that landfills must be closed with a final cover designed and constructed to:

- (1) Provide long-term minimization of migration of liquids through the closed landfill;
- (2) Function with minimum maintenance;
- (3) Promote drainage and minimize erosion or abrasion of the cover;
- (4) Accommodate settling and subsidence so that the cover's integrity is maintained; and
- (5) Have a permeability less than or equal to the permeability of any bottom liner system or natural soils present.

Part 265.310(b) details the maintenance and monitoring requirements that must be implemented throughout the post-closure care period. Under these requirements, DOE must:

- (1) Maintain the integrity and effectiveness of the final cover, including making repairs to the cover as necessary to correct the effects of settling, subsidence, erosion, or other events;
- (2) Maintain and monitor leak detection systems (if applicable);
- (3) Maintain and monitor the groundwater monitoring system and comply with all other applicable requirements;
- (4) Prevent run-on and run-off from eroding or otherwise damaging the final cover; and
- (5) Protect and maintain surveyed benchmarks.

As described in Section 3.1, an ET cover system will be designed and constructed at the Present Landfill to reduce infiltration and eliminate groundwater inflow into the landfill. With reduced infiltration and elimination of groundwater inflow, the need for further maintenance will be minimized, as will the post-closure escape of hazardous waste, hazardous constituents, leachate, contaminated run-off, and hazardous waste decomposition products to groundwater and surface water. In addition, post-closure monitoring,

68

maintenance, and access controls will be implemented to maintain the integrity and effectiveness of the ET cover, as described in Section 5.0.

8.2 Air

The proposed action has the potential to generate fugitive particulates and hazardous air pollutant emissions. Subpart H of 40 CFR 61 contains the requirements for monitoring and reporting activities within DOE facilities that have the potential to emit radionuclides other than radon.

Colorado Regulation No. 1 (5 CCR 1001-3) governs opacity and particulate emissions. Section II of Regulation No. 1 addresses opacity and prohibits stack emissions from fuel-fired equipment exceeding 20 percent opacity. Section III addresses the control of particulate emissions. Fugitive particulate emissions will be generated from construction and transportation activities. During construction activities, dust minimization techniques, such as water sprays, will be used to minimize suspension of particulates. In addition, demolition operations will not be conducted during periods of high wind. The substantive requirements of Regulation No. 1 will be incorporated into a Dust Control Plan, which will define the level of particulate control for the project.

Colorado Regulation No. 3 (5 CCR 1001-5) provides CDPHE with the authority to inventory emissions and Part A describes Air Pollutant Emission Notice (APEN) requirements. Air quality management subject matter experts will evaluate the project and, if applicable, and APEN will be prepared to facilitate CDPHE's inventory process.

8.3 Water

Remediation wastewater generated during construction activities will be managed consistent with provisions of the RFCA IGD (DOE, CDPHE, EPA, 1999). Remediation wastewater will be collected, characterized, and transferred to an approved treatment unit for processing (i.e., the Site sewage treatment plant or to another approved on-Site or off-Site treatment facility), or it will be directly discharged in accordance with the Site requirements for control and disposition of incidental waters. In addition, all discharges of storm water and treated wastewater into surface water bodies will meet the applicable substantive requirements.

8.4 Solid Waste

Solid wastes generated during construction of the ET cover will be managed in accordance with CDPHE's solid waste regulations (6 CCR 1007-2). No hazardous or radioactive wastes will be generated during construction activities.

8.5 Wetlands

As described in Section 2.7, wetlands have been designated along the shoreline of the East Landfill Pond by the U.S. Army Corps of Engineers. The loss of jurisdictional wetlands due to the proposed action will be mitigated using the Standley Lake wetland mitigation bank (if available), or by purchasing offsite wetland mitigation credits.

69

8.6 Wildlife

Construction activities may impact migratory birds protected by the Migratory Bird Treaty Act, and the Fish and Wildlife Conservation Act. Due to the variations in potential impacts depending upon the season and the nesting schedules for migratory birds, the substantive requirements of these federal statutes will be evaluated by the Site's Ecology group prior to conducting activities associated with the proposed action. The substantive requirements identified during the evaluation will be implemented throughout the construction process.

8.7 Mineral Resources

The Colorado Land Reclamation Act for the Extraction of Construction Materials (CRS 34-32.5-101) governs the extraction of construction materials, including sand and gravel. In the event an onsite location is used as a source of material for the Present Landfill cover, a Reclamation Plan will be prepared and implemented in accordance with the substantive requirements of the Mineral Rules and Regulations of the Colorado Mined Land Reclamation Board.

9.0 IMPLEMENTATION SCHEDULE

A copy of the current implementation schedule is provided in Appendix C. The schedule is not an enforceable part of this IM/IRA and DOE or its contractor may alter the schedule without prior notification to or approval by the regulatory agencies. Significant schedule changes will be shared with the agencies as part of the RFCA consultative process.

21

10.0 CLOSEOUT REPORT

Upon completion of IM/IRA activities at the Present Landfill, a Closeout Report will be prepared in accordance with RFCA. The Closeout Report will consist of a brief description of the work completed. The expected outline for the Closeout Report is shown below:

- Introduction
- Remedial action description
- Dates and durations of specific activities (approximate)
- Verification that remedial action goals have been met
- Deviations from the decision document
- Final disposition of wastes (actual or anticipated)
- RCRA unit closure information

Upon completion, the Closeout Report will be submitted for review and concurrence by CDPHE and EPA, and placed in the Administrative Record File.

11.0 COMMENT RESPONSIVENESS SUMMARY

Responses to comments received during the formal public comment period, including comments from the regulatory agencies, are documented in Appendix D.

73

12.0 REFERENCES

- Baedecker, J.J. and W. Back, 1979, "Modern Marine Sediments as a Natural Analog to the Chemically Stressed Environment of a Landfill," *Journal of Hydrology*, 43:393-414.
- DOE, 1991, Phase I RFI/RI Work Plan for Operable Unit 7, U.S. Department of Energy, Rocky Flats Environmental Technology Site, Golden, CO.
- DOE, 1994, Final Work Plan for Operable Unit No. 7 (Present Landfill), U.S. Department of Energy, Rocky Flats Environmental Technology Site, Golden, CO.
- DOE, 1996, Operable Unit 7 Revised Draft IM/IRA Decision Document and Closure Plan, RF/ER-96-0009.UN, Kaiser-Hill Company, L.L.C., Rocky Flats Environmental Technology Site, Golden, CO, March 1996.
- DOE, 1997, Rocky Flats Cumulative Impacts Document, U.S. Department of Energy, Rocky Flats Environmental Technology Site, Golden, CO, July 1997.
- DOE, 2000a, Rocky Flats Environmental Site FY2001 Integrated Monitoring Plan, Rocky Flats Environmental Technology Site, Golden, CO, November 2000.
- DOE, 2000b, RFCA Standard Operating Protocol for Facility Disposition, U.S. Department of Energy, Rocky Flats Environmental Technology Site, Golden, CO, August 14, 2000.
- DOE, 2001a, Rocky Flats Cumulative Impacts Document, 2000 Update, Department of Energy, Rocky Flats Environmental Technology Site, Golden, CO.
- DOE, 2001b, 2000 Annual Rocky Flats Cleanup Agreement Groundwater Monitoring Report, 01-RF-02107, Rocky Flats Environmental Technology Site, Golden, CO.
- DOE, 2001c, Long-Term Stewardship Study, Volume I Report, U.S. Department of Energy.
- DOE, CDPHE, EPA, 1996, Final Rocky Flats Cleanup Agreement, U.S. Department of Energy, Colorado Department of Public Health and Environment, and U.S. Environmental Protection Agency, July 1996.
- DOE, CDPHE, EPA, 1999, RFCA Implementation Guidance Document (IGD), Attachment 3 to the Final Rocky Flats Cleanup Agreement, July 19, 1999.
- EG&G, 1992, Background Geochemical Characterization Report, Rocky Flats Environmental Technology Site, August 30, 1992.
- EG&G, 1994, Borrow Source Evaluation for Closure of the OUs and OU7 Landfill, Rocky Flats Environmental Technology Site, Golden, Colorado, EG&G Rocky Flats, November 17, 1994.
- EPA, 1988, CERCLA Compliance with Other Laws Manual: Interim Final, U.S. Environmental Protection Agency, August 1988.
- EPA, 1989, CERCLA Compliance with Other Laws Manual: Part II, Clean Air Act and Other Environmental Statutes and State Requirements, EPA/540/G-89/009, U.S. Environmental Protection Agency, August 1989.

EPA, 1993, Presumptive Remedy for CERCLA Municipal Landfill Sites, EPA 540-F-93-035, Directive No. 9355.0-49FS, U. S. Environmental Protection Agency, September 1993.

K-H, 2000a, Rocky Flats Environmental Technology Site Integrated Work Control Program, MAN-071-IWCP, Revision 3, Kaiser-Hill Company, L.L.C., Rocky Flats Environmental Technology Site, Golden, CO.

K-H, 2000b, Rocky Flats Environmental Technology Site Conduct of Operations Manual, MAN-066-COOP, Revision 0, Kaiser-Hill Company, L.L.C., Rocky Flats Environmental Technology Site, Golden, CO.

K-H, 2000c, Rocky Flats Environmental Technology Site Occupational Safety and Industrial Hygiene Program Manual, MAN-072-OS&IHPM, Revision 0, Kaiser-Hill Company, L.L.C., Rocky Flats Environmental Technology Site, Golden, CO.

K-H, 2001a, Evaluation of Groundwater Control Systems at the Present Landfill (OU 7), Kaiser-Hill Company, L.L.C., Rocky Flats Environmental Technology Site, Golden, CO, December 2001.

K-H, 2001b, Control and Disposition of Incidental Waters, 1-C91-EPR-SW.01, Rocky Flats Environmental Technology Site, Golden, Colorado, October 24, 2001.

K-H, 2001c, Environmental Restoration Program Management Assessment of Readiness, Revision 0, Kaiser-Hill Company, L.L.C., Rocky Flats Environmental Technology Site, Golden, CO, August 2001.

K-H, 2001d, Environmental Restoration Program Quality Assurance Program Plan, Revision 0, Kaiser-Hill Company, L.L.C., Rocky Flats Environmental Technology Site, Golden, CO, October 2001.

K-H, 2002a, Conceptual Design for the Present Landfill Cover, Kaiser-Hill Company, L.L.C., Rocky Flats Environmental Technology Site, Golden, CO, April 2002.

K-H, 2002b, Landfill Gas Generation Report (Appendix E to the Conceptual Design for the Present Landfill Cover [K-H 2002a]).

K-H, 2002c, Update on Testing and Monitoring Requirements for Alternative Landfill Covers in the Western United States (Appendix C to the Conceptual Design for the Present Landfill Cover [K-H 2002a]).

K-H, 2002d, Environmental Restoration Operations Plan, Kaiser-Hill Company, L.L.C., Rocky Flats Environmental Technology Site, Golden, CO, Revision 1, June 15, 2002.

K-H, 2002e, Environmental Restoration Program Waste Management Plan, Kaiser-Hill Company, L.L.C., Rocky Flats Environmental Technology Site, Golden, CO, January 2002.

Rocky Flats Stewardship Working Group, 2002, Tools for Long-Term Planning: The Rocky Flats Stewardship Toolbox, March 2002.

APPENDIX A

PRESENT LANDFILL DATA SUMMARIES

Table A-1. Analytes Detected in Leachate at the Seep

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Mean	Background UTL _{99.99} Concentration	Units	PCOC
Metals										
Aluminum	10 - 200	8/9	29	3,800	—	V	6,500	180,000	µg/l	
Antimony	0.05 - 60	1/9	14	15	—	V	12	39,000	µg/l	
Arsenic	0.7 - 10	3/7	1.4	2.3	—	JA	1	4,700	µg/l	
Barium	0.02 - 200	9/9	530	700	—	V	5,930	93,000	µg/l	2
Beryllium	0.2 - 5	2/9	0.5	1.4	—	JA	1	3,000	µg/l	
Calcium	14.5 - 5,000	9/9	126,000	150,000	—	V	140,000	510,000	µg/l	2,3
Chromium	2.4 - 27.5	3/9	2.0	13	—	JA	6	5,000	µg/l	
Cobalt	2.6 - 50	6/9	3.6	9.4	—	JA	5	32,000	µg/l	
Copper	2.4 - 25	4/9	2.0	6.6	—	JA	4	12,000	µg/l	
Iron	4.7 - 100	9/9	70,000	120,000	—	V	86,000	1,900,000	µg/l	2,3
Lead	0.8 - 20	8/8	1.6	11	—	V	5	2,000	µg/l	
Lithium	2 - 100	9/9	34	46	—	V	40	63,000	µg/l	2
Magnesium	0.1 - 5,000	9/9	29,000	33,000	—	V	31,000	1,200,000	µg/l	2,3
Manganese	1 - 15	9/9	1,300	1,500	—	V	1,400	19,000	µg/l	2
Molybdenum	5.7 - 200	4/9	4.0	21	—	JA	8	66,000	µg/l	
Nickel	0.02 - 40	3/9	5.0	31	—	V	11	25,000	µg/l	
Potassium	10 - 5,000	9/9	5,500	7,600	—	V	6,400	2,400,000	µg/l	2,3
Selenium	1.1 - 5	1/9	1.1	1.4	—	JA	2	3,200	µg/l	
Silver	2.6 - 25	3/9	2.7	5.1	—	JA	3,000	6,800	µg/l	
Sodium	10 - 5,000	9/9	55,000	67,100	—	V	63,000	30,000	µg/l	1,2,3
Strontium	3.5 - 200	9/9	810	980	—	V	890	480,000	µg/l	2
Tin	10 - 200	3/9	11	57	—	V	20	63,000	µg/l	
Vanadium	3.2 - 50	6/9	3.1	19	—	JA	7.6	24,000	µg/l	
Zinc	1.8 - 20	9/9	857	2,600	—	V	20	8,600	µg/l	2,5
Radionuclides										
Americium-241	0 - 0.01	9/9	-0.0004	0.02	—	A	0.006	0.06	pCi/l	
Cesium-137	0.47 - 1	6/6	0.0305	0.61	J	—	0.26	2.0	pCi/l	
Gross alpha	1.5 - 3.5	5/5	0.89	6.6	—	V	3.3	330	pCi/l	
Gross beta	2.9 - 8.7	5/5	7.2	17	—	V	12	11	pCi/l	1,2,6
Plutonium-239/240	0 - 0.013	9/9	0.001	0.016	—	A	0.007	3.00	pCi/l	
Strontium-89/90	0.21 - 1	6/6	0.66	4.1	—	V	1.4	1.6	pCi/l	1,2
Tritium	155 - 450	11/11	190	1,500	—	A	430	4.6	pCi/l	1
Uranium-233/234	0.1 - 0.3	7/7	-0.024	4.2	B	A	0.8	5.00	pCi/l	
Uranium-235	0.033 - 0.27	7/7	-0.012	0.084	J	A	0.033	0.3	pCi/l	
Uranium-238	0.086 - 0.32	7/7	0.039	3	—	A	1	5.3	pCi/l	

77

Table A-1. Analytes Detected in Leachate at the Seep

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Mean	Background UTL _{max} Concentration	Units	PCOC
Semivolatile Organic Compounds										
2,4-Dimethylphenol	10	1/5	3	3	J	A	5	—	µg/l	4
2-Methylnaphthalene	10	5/5	12	23	—	V	16	—	µg/l	4
4-Methylphenol	10	3/5	2	4	J	—	4	—	µg/l	4
Acenaphthene	10	5/5	2	3	J	A	3	—	µg/l	4
Bis(2-ethylhexyl)phthalate	10 - 12	1/5	2	2	J	A	2	18	µg/l	4
Dibenzofuran	10	5/5	1	2	J	A	1	—	µg/l	4
Diethyl phthalate	10	4/5	1	3	J	A	3	11	µg/l	4
Fluorene	10	5/5	2	3	J	A	2	—	µg/l	4
Naphthalene	10	5/5	14	22	—	V	18	—	µg/l	4
Phenanthrene	10	5/5	4	5	J	A	4	—	µg/l	4
Volatile Organic Compounds										
1,1-Dichloroethane	5	10/11	5	10	—	V	7	—	µg/l	4
1,2-Dichloroethene	5	4/11	4	5	—	—	3	—	µg/l	4
2-Butanone	10	2/11	6	6	J	—	5	—	µg/l	4
Acetone	10	3/11	10	25	—	V	11	92	µg/l	4
Benzene	5	4/11	1	2	J	—	2	—	µg/l	4
Chloroethane	10	10/11	10	57	—	V	30	6	µg/l	4
Chloromethane	10	1/11	7	7	J	A	5	—	µg/l	4
Ethylbenzene	5	10/11	5	17	—	V	13	—	µg/l	4
Methylene chloride	5	4/11	3	6	B	—	5	23	µg/l	4
Toluene	5	10/11	5	47	—	—	26	4	µg/l	4
Total xylenes	5	10/11	5	24	—	V	15	—	µg/l	4
Trichloroethene	5	3/11	1	2	J	—	2	—	µg/l	4
Vinyl chloride	10	2/11	8	11	—	V	6	—	µg/l	4
Indicator Parameters										
Bicarbonate as CaCO ₃	10,000	11/11	554,000	705,000	—	V	590,000	—	µg/l	
Chloride	2,500 - 50,000	11/11	40,000	66,300	—	V	57,000	88,000	µg/l	2
Dissolved organic carbon	1,000	4/4	14,000	27,000	—	JA	19,000	—	µg/l	
Fluoride	100 - 200	10/10	390	540	—	V	460	—	µg/l	
Nitrate/nitrite	100 - 200	5/7	100	870	—	V	300	5,300	µg/l	
Nitrite	20	4/7	20	63	—	V	30	68	µg/l	2

78

Table A-1. Analytes Detected in Leachate at the Seep

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Mean	Background UTL _{max} Concentration	Units	PCOC
Oil and grease	5,000 - 11,100	2/7	5,000	42,100	—	V	10,000	—	µg/l	
Orthophosphate	50	1/70	50	99	—	V	36	—	µg/l	
Phosphorus	50	7/7	95	120	—	V	110	—	µg/l	
Silica	400 - 2,000	3/3	7,400	43,000	—	—	19,567	—	µg/l	
Silicon	7.3 - 26	11/11	7,060	18,300	—	V	11,000	—	µg/l	
Solids, nonvolatile suspended	5,000	6/6	10,000	199,000	—	—	83,167	—	µg/l	
Sulfate	500 - 25,000	5/11	460	29,600	—	V	6,280	230,000	µg/l	
Total dissolved solids	10,000	11/11	470,000	820,000	—	V	700,000	—	µg/l	
Total organic carbon	1,000	3/3	19,000	24,500	—	V	20,833	—	µg/l	
Total suspended solids	5,000	8/8	10,000	210,000	—	V	130,000	—	µg/l	

Table A-2. Analytes Detected in East Landfill Pond Surface Water

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Mean	Background UTL ^{www} Concentration	Units	PCOC
Metals										
Aluminum	20 - 200	10/15	30	190	—	V	56	39,000	µg/l	
Arsenic	0.7 - 10	5/14	0.9	2.2	—	V	1	3,500	µg/l	
Barium	1.3 - 200	15/15	16	250	—	V	170	64,000	µg/l	2
Beryllium	0.5 - 5	1/15	0.5	0.7	—	JA	1	1,700	µg/l	
Cadmium	2.4 - 5	1/15	1	2.1	—	JA	2	1,800	µg/l	
Calcium	14.3 - 5,000	15/15	3,200	55,000	—	V	39,000	57,000	µg/l	2,3
Cesium	100 - 1,000	1/16	33	50	—	V	180	480,000	µg/l	
Chromium	2.4 - 10	1/15	2	3.2	—	JA	3	3,300	µg/l	
Copper	2.1 - 25	4/15	2	16	—	JA	4	8,300	µg/l	
Iron	4.3 - 100	15/15	16	1,200	—	V	490	17,000	µg/l	
Lead	0.8 - 3	5/14	0.9	5.3	—	JA	2	1,500	µg/l	
Lithium	2 - 100	14/14	7.7	110	—	—	77	36,000	µg/l	2
Magnesium	30 - 5,000	15/15	4,300	45,800	—	V	37,000	1,200,000	µg/l	2,3
Manganese	1 - 15	14/15	2.5	430	—	V	100	3,000	µg/l	2
Mercury	0.2	2/15	0.2	0.54	—	V	0.1	59	µg/l	
Molybdenum	5.7 - 200	1/14	3	13	B	—	6	33,000	µg/l	2
Nickel	3.9 - 40	8/15	6.3	17	—	V	8	13,000	µg/l	2
Potassium	95 - 5,000	15/15	1,400	11,000	—	V	8,400	1,600,000	µg/l	2,3
Silver	2.5 - 10	1/15	2	2.9	—	V	2	3,000	µg/l	
Sodium	21 - 5,000	15/15	20,000	190,000	—	V	160,000	39,000	µg/l	1,2,3
Strontium	2.3 - 200	14/14	45	600	—	V	460	240,000	µg/l	2
Thallium	1.2 - 10	1/14	1	7.4	—	JA	1	6,500	µg/l	
Tin	10 - 200	3/14	10	26	B	—	12	34,000	µg/l	
Vanadium	2 - 50	1/15	2	5.6	B	—	2	17,000	µg/l	
Zinc	1.8 - 20	12/15	4	26	—	V	10	3,700	µg/l	
Radionuclides										
Americium-241	0 - 0.19	11/11	0.00057	0.031	U	A	0.007	0.03	pCi/l	1
Cesium-137	0.58 - 1.2	6/6	-0.17	-0.044	J	A	-0.11	2.1	pCi/l	
Gross alpha	2 - 8.7	6/6	-0.67	5	U	V	1	29	pCi/l	2,6
Gross beta	2.6 - 6.8	6/6	7.9	16	—	V	11	31	pCi/l	2,6
Plutonium-239	0.14 - 0.03	3/3	0	0.005	U	A	0.002	—	pCi/l	
Plutonium-239/240	0 - 0.01	9/9	-0.00036	0.023	—	A	0.004	0.03	pCi/l	
Radium-226	0.21	1/1	0.23	0.23	—	V	0.23	17	pCi/l	
Strontium-89/90	0.23 - 1	5/5	0.66	1.9	—	A	1.4	4.9	pCi/l	2
Strontium-90	0.36 - 0.58	5/5	0.7084	1.208	—	V	1.02	—	pCi/l	
Tritium	160 - 460	13/13	86	260	J	V	160	730	pCi/l	2

Table A-2. Analytes Detected in East Landfill Pond Surface Water

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Mean	Background UTL max Concentration	Units	PCOC
Uranium-233/234	0 - 0.23	5/5	0.76	1.6	—	A	1.1	2.2	pCi/l	2
Uranium-235	0 - 0.26	5/5	0.036	0.3	—	A	0.2	0.3	pCi/l	1,2
Uranium-238	0.094 - 0.263	5/5	0.70	2	—	A	1.2	1.8	pCi/l	1,2
Semivolatile Organic Compounds										
Bis(2-ethylhexyl)phthalate	9 - 11	1/7	1	1	J	A	5	8	µg/l	4
Di-n-butyl phthalate	9 - 11	1/7	1	1	J	A	5	—	µg/l	4
Volatile Organic Compounds										
Methylene chloride	5	2/15	4	8	B	—	3	21	µg/l	4
Indicator Parameters										
Bicarbonate as CaCO ₃	1,000 - 10,000	14/14	213,000	489,000	—	V	390,000	—	µg/l	
Carbonate	10,000	1/4	10,000	15,300	—	V	7,600	—	µg/l	
Carbonate as CaCO ₃	1,000 - 10,000	7/10	10,000	77,000	—	V	33,000	—	µg/l	
Chloride	200 - 25,000	14/14	140,000	180,000	—	—	160,000	64,000	µg/l	1,2
Dissolved organic carbon	1,000 - 2,000	6/6	22,000	32,000	—	V	27,000	—	µg/l	
Fluoride	100 - 200	13/13	590	890	—	—	770	—	µg/l	
Nitrate	100	1/3	100	200	—	JA	100	—	µg/l	
Nitrate/nitrite	20 - 100	6/11	40	320	—	JA	93	3,100	µg/l	
Oil and grease	200 - 7,100	1/10	500	500	—	—	2,500	—	µg/l	
Orthophosphate	10 - 50	1/10	40	40	—	—	27	—	µg/l	
pH	—	4/4	8.2	8.3	—	—	8.2	—	pH	
Phosphorus	50	2/9	50	76	—	V	35	—	µg/l	
Silica	400	1/1	3,100	3,100	—	—	3,100	—	µg/l	
Silicon	7.3 - 100	13/13	300	3,700	—	V	2,300	16,000	µg/l	
Solids, nonvolatile suspended	5,000	2/6	5,000	12,000	—	V	5,000	—	µg/l	
Sulfate	500 - 10,000	14/14	7,000	26,000	—	V	16,000	41,000	µg/l	
Total dissolved solids	10,000	14/14	570,000	810,000	—	V	730,000	—	µg/l	
Total organic carbon	1,000 - 2,000	6/6	26,000	51,000	—	—	34,000	—	µg/l	
Total suspended solids	4,000 - 5,000	1/9	4,000	12,000	—	—	3,500	—	µg/l	

Table A-3. Analytes Detected in East Landfill Pond Sediments

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Location of Maximum Detection	Mean	Background UTL ^{100%} Concentration*	Units	PCOC
Metals											
Aluminum	7.7 - 12	2/2	12,000	17,000	—	V	SED70193	15,000	30,000	mg/kg	
Arsenic	0.32 - 0.42	3/3	2.7	5	—	V	SED70193	4	67	mg/kg	
Barium	1.6 - 2.5	3/3	170	220	—	V	SED70093	200	800	mg/kg	
Beryllium	0.22 - 0.34	3/3	0.81	1.5	—	JA	SED70193	1.2	2.6	mg/kg	
Calcium	7.5 - 12	2/2	6,300	7,900	—	V	SED70193	7,100	81,000	mg/kg	
Chromium	0.64 - 0.99	3/3	12	18	—	V	SED70193	15	30	mg/kg	
Cobalt	0.64 - 0.99	3/3	5.7	7.6	—	V	SED70093	6.8	—	mg/kg	
Copper	0.71 - 1.1	3/3	11	19	—	V	SED70193	16	180	mg/kg	
Iron	1.8 - 2.8	2/2	12,000	15,000	—	V	SED70193	14,000	140,000	mg/kg	
Lead	2.5 - 3.8	3/3	22	34	—	V	SED70193	30	260	mg/kg	
Lithium	0.83 - 1.3	2/2	6.1	9.9	—	V	SED70193	8	—	mg/kg	
Magnesium	9.5 - 15	2/2	2,200	3,300	—	V	SED70193	2,700	6,500	mg/kg	
Manganese	0.59 - 0.91	2/2	150	190	—	V	SED70193	170	—	mg/kg	
Nickel	2.7 - 4.2	3/3	9.3	15	—	V	SED70093	13	35	mg/kg	
Potassium	190 - 300	2/2	1,400	2,600	—	V	SED70193	2,000	3,200	mg/kg	
Selenium	0.3 - 0.5	3/3	0.41	1.1	—	JA	SED70193	0.8	5.2	mg/kg	
Silicon	1.8 - 2.8	2/2	230	340	—	V	SED70193	290	—	mg/kg	
Silver	0.88 - 1.4	1/3	0.88	0.88	—	JA	SED70293	0.7	—	mg/kg	
Sodium	15 - 23	2/2	290	450	—	V	SED70193	370	2,100	mg/kg	
Strontium	1.3 - 2.1	2/2	44	62	—	V	SED70193	53	360	mg/kg	
Tin	4.1 - 6.3	1/3	5.3	5.3	—	V	SED70293	3.8	—	mg/kg	
Vanadium	0.78 - 1.2	3/3	29	41	—	V	SED70193	34	86	mg/kg	
Zinc	0.59 - 0.91	3/3	49	190	—	V	SED70093	110	150	mg/kg	1
Radionuclides											
Americium-241	0.0021 - 0.0041	3/3	0.0045	0.018	—	A	SED70093	0.012	—	pCi/g	
Cesium-137	0	3/3	0.29	0.73	X	—	SED70093	0.46	3.5	pCi/g	
Gross alpha	2.5 - 3.1	3/3	11	16	—	V	SED70193	15	—	pCi/g	
Gross beta	1.9 - 2.1	3/3	28	29	—	V	SED70093	28	—	pCi/g	
Plutonium-239/240	0.0087 - 0.015	3/3	0.0072	0.098	—	A	SED70093	0.045	—	pCi/g	
Strontium-89/90	0.042 - 0.074	3/3	0.12	0.24	—	V	SED70093	0.17	—	pCi/g	
Uranium-233/234	0.042 - 0.098	3/3	0.91	1.1	—	A	SED70093	1.0	—	pCi/g	
Uranium-235	0.05 - 0.062	3/3	0.055	0.074	—	A	SED70193	0.062	—	pCi/g	
Uranium-238	0.056 - 0.076	3/3	0.81	1.4	—	A	SED70093	1.2	—	pCi/g	
Semivolatile Organic Compounds											
Acenaphthene	450 - 790	1/3	100	100	J	A	SED70093	220	—	µg/kg	2
Anthracene	450 - 790	1/3	160	160	J	A	SED70093	240	—	µg/kg	2
Benzo(a)anthracene	450 - 790	1/3	340	340	J	A	SED70093	300	—	µg/kg	2

82

Table A-3. Analytes Detected in East Landfill Pond Sediments

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Location of Maximum Detection	Mean	Background UTL _{min} Concentration*	Units	PCOC
Benzo(a)pyrene	450 - 790	1/3	320	320	J	A	SED70093	290	—	µg/kg	2
Benzo(b)fluoranthene	450 - 790	1/3	450	470	J	A	SED70093	340	—	µg/kg	2
Benzo(ghi)perylene	450 - 790	1/3	200	200	J	A	SED70093	250	—	µg/kg	2
Benzo(k)fluoranthene	450 - 790	1/3	130	130	J	A	SED70093	230	—	µg/kg	2
Benzoic acid	2,200 - 3,900	3/3	260	870	J	A	SED70093	540	—	µg/kg	2
Bis(2-chloroisopropyl)ether	450 - 790	1/3	47	47	J	A	SED70293	260	—	µg/kg	2
Bis(2-ethylhexyl) phthalate	450 - 790	1/3	80	80	J	A	SED70093	210	—	µg/kg	2
Chrysene	450 - 790	1/3	310	310	J	A	SED70093	290	—	µg/kg	2
Fluoranthene	450 - 790	2/3	79	830	—	V	SED70093	420	—	µg/kg	2
Fluorene	450 - 790	1/3	92	92	J	A	SED70093	220	—	µg/kg	2
Indeno(1,2,3-cd) pyrene	450 - 790	1/3	180	180	J	A	SED70093	250	—	µg/kg	2
Phenanthrene	450 - 790	2/3	73	630	J	A	SED70093	350	—	µg/kg	2
Pyrene	450 - 790	2/3	74	750	J	A	SED70093	390	—	µg/kg	2
Volatile Organic Compounds											
2-Butanone	13 - 24	1/3	13	35	—	V	SED70093	17	—	µg/kg	2
Acetone	13 - 24	2/3	63	130	B	V	SED70193	68	—	µg/kg	2
Toluene	10 - 33	3/3	180	440	—	V	SED70293	310	—	µg/kg	2
Indicator Parameters											
% Solids	0.1	4/4	42	76	—	V	SED70293	54	—	%	
pH	0.2	3/3	6.7	7.2	—	V	SED70193	7	—	pH	
Total organic carbon	500	3/3	7,800	9,400	X	V	SED70293	8,400	—	mg/kg	

82

**Table A-4. Analytes Detected in Subsurface Geologic Materials
Downgradient of Present Landfill**

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Location of Maximum Detection	Mean	Background UTL _{99.99} Concentration	Units	PCOC
Colluvial Material (Qc)											
Metals											
Aluminum	6.9 - 7.8	7/7	10,000	16,000	—	V	71093	13,000	28,000	mg/kg	
Arsenic	0.24 - 0.36	7/7	3.3	7.9	—	V	70993	5	9	mg/kg	
Barium	1.4 - 1.6	7/7	91	620	—	JA	71093	230	470	mg/kg	I
Beryllium	0.2 - 0.22	7/7	0.74	1.2	—	JA	70993	1	25	mg/kg	
Calcium	6.7 - 7.6	7/7	5,600	7,400	—	V	71093	6,400	31,000	mg/kg	
Chromium	0.56 - 0.64	7/7	11	17	—	V	71093	13	37	mg/kg	
Cobalt	0.56 - 0.64	7/7	5.6	11	—	V	71093	9	17	mg/kg	
Copper	0.63 - 0.72	7/7	13	18	—	V	71093	15	33	mg/kg	
Iron	1.6 - 1.9	7/7	12,000	18,000	—	V	71093	14,000	39,000	mg/kg	
Lead	2 - 2.6	7/7	17	28	—	JA	71093	23	32	mg/kg	
Lithium	0.74 - 0.84	7/7	6.1	9.9	—	V	71093	8	23	mg/kg	
Magnesium	8.4 - 9.6	7/7	2,500	3,600	—	V	71093	2,900	7,900	mg/kg	
Manganese	0.52 - 0.59	7/7	110	260	—	V	70993	200	750	mg/kg	
Nickel	2.4 - 2.7	7/7	13	18	—	V	71093	15	42	mg/kg	
Potassium	169 - 193	7/7	970	1,800	—	V	71093	1,300	3,200	mg/kg	
Selenium	0.26 - 0.34	7/7	0.34	0.74	—	JA	70993	0.52	7	mg/kg	
Silicon	1.6 - 1.8	7/7	320	660	—	JA	71093	410	—	mg/kg	
Sodium	13 - 15	7/7	85	910	—	V	70993	380	3,004	mg/kg	
Strontium	1.2 - 1.4	7/7	50	110	—	V	71093	67	140	mg/kg	
Tin	3.6 - 4.1	5/7	3.7	8.9	—	JA	71093	5.6	630	mg/kg	
Vanadium	0.69 - 0.79	7/7	21	44	—	V	71093	28	73	mg/kg	
Zinc	0.52 - 0.59	7/7	55	72	—	V	71093	61	130	mg/kg	
Radionuclides											
Americium-241	0	6/6	0.0012	0.014	J	A	71093	0.0061	—	pCi/g	
Cesium-137	0.1 - 0.1	6/6	-0.014	0.24	—	—	71093	0.058	0.1	pCi/g	I
Gross alpha	0.8 - 3.4	6/6	8	17	—	V	70993	14	65	pCi/g	
Gross beta	2.3 - 2.5	6/6	22	26	—	V	70993	24	40	pCi/g	
Plutonium-239/240	0 - 0.016	4/4	0.0025	0.018	J	A	70993	0.011	—	pCi/g	
Radium-226	0.5	6/6	0.84	1.1	—	—	70993	0.97	2	pCi/g	
Radium-228	0.5	6/6	1.3	1.9	—	—	70993	1.6	3	pCi/g	
Strontium-89/90	0.04 - 0.06	6/6	0.1	0.42	J	A	71093	0.19	1.2	pCi/g	
Tritium	450 - 450	6/6	98	300	J	V	70993	170	460	pCi/g	
Uranium-233/234	0.029 - 0.081	6/6	0.79	1.2	—	A	71093	0.97	—	pCi/g	
Uranium-235	0 - 0.042	6/6	0.026	0.054	J	A	70993	0.053	0.2	pCi/g	
Uranium-238	0 - 0.057	6/6	0.96	1.2	—	A	71093	1.1	2	pCi/g	

**Table A-4. Analytes Detected in Subsurface Geologic Materials
Downgradient of Present Landfill**

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Location of Maximum Detection	Mean	Background UTL _{max} Concentration	Units	PCOC
Semivolatile Organic Compounds											
Chrysene	380 - 440	1/7	43	43	J	A	70993	180	—	µg/kg	3
Fluoranthene	380 - 440	1/7	110	110	J	A	70993	190	—	µg/kg	3
Phenanthrene	380 - 440	1/7	100	100	J	A	70993	190	—	µg/kg	3
Pyrene	380 - 440	1/7	110	110	J	A	70993	190	—	µg/kg	3
Volatile Organic Compounds											
4-Methyl-2-pentanone	12 - 14	1/5	12	58	—	V	70993	17	—	µg/kg	3
Toluene	12 - 64	5/5	160	2,000	—	V	70993	850	—	µg/kg	3
Total xylenes	6 - 7	1/5	2	2	J	A	70993	3	—	µg/kg	3
Indicator Parameters											
% solids	0.1	7/7	74	86	—	V	71093	81	—	%	
Nitrate	1	2/5	1	2	—	JA	70993	1	—	mg/kg	
Nitrate/nitrite	1	3/5	1	20,000	—	V	71093	4,000	66	mg/kg	1
Total organic carbon	0.05	5/5	500	21,000	—	V	71093	8,500	—	mg/kg	
pH	0.2	7/7	7.8	8.4	—	V	70993	8.1	—	pH	
Weathered Bedrock Material (KaKI-w)											
Metals											
Aluminum	5.8 - 7.5	11/11	5,300	7,900	—	V	70993	7,000	43,000	mg/kg	
Arsenic	0.19 - 1.4	11/11	1.3	11	—	V	70993	3.4	10	mg/kg	1
Barium	1.2 - 1.5	11/11	25	250	—	JA	71093	97	210	mg/kg	1
Beryllium	0.16 - 0.21	11/11	0.53	1.1	—	JA	71093	1	9	mg/kg	
Cadmium	0.49 - 0.64	4/11	0.49	1.5	—	V	71093	0.5	—	mg/kg	
Calcium	5.6 - 7.3	11/11	2,800	16,000	—	V	71093	6,000	8,300	mg/kg	1.2
Chromium	0.48 - 0.61	11/11	6.4	11	—	V	71093	8	53	mg/kg	
Cobalt	0.48 - 0.61	11/11	2.2	21	—	V	71093	9	17	mg/kg	1
Copper	0.53 - 0.68	11/11	13	24	—	V	71093	19	44	mg/kg	
Iron	1.4 - 1.8	11/11	4,900	25,000	—	V	71093	14,000	36,000	mg/kg	
Lead	1 - 2.3	11/11	13	31	—	JA	70993	22	26	mg/kg	1
Lithium	0.62 - 0.8	11/11	3.4	10	—	V	70993	7	24	mg/kg	
Magnesium	7.1 - 9.2	11/11	1,800	3,100	—	V	71093	2,500	7,200	mg/kg	
Manganese	0.44 - 0.57	11/11	20	900	—	JA	71093	280	710	mg/kg	1
Mercury	0.08 - 0.11	2/11	0.08	0.18	—	JA	70993	0.1	—	mg/kg	
Nickel	2 - 2.6	11/11	3.1	38	—	V	71093	17	52	mg/kg	
Potassium	143 - 184	11/11	830	1,300	—	V	71093	990	3,400	mg/kg	
Selenium	0.23 - 0.3	7/11	0.27	1.9	—	JA	71093	0.8	—	mg/kg	
Silicon	1.3 - 1.7	11/11	220	1200	—	JA	71093	590	—	mg/kg	
Silver	0.66 - 0.85	2/11	0.66	0.89	—	V	71093	0.5	62	mg/kg	
Sodium	11 - 15	11/11	260	940	—	V	70993	500	2,800	mg/kg	
Strontium	1 - 1.3	11/11	47	200	—	V	71093	97	32	mg/kg	1

**Table A-4. Analytes Detected in Subsurface Geologic Materials
Downgradient of Present Landfill**

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Location of Maximum Detection	Mean	Background UTL _{95%} Concentration	Units	PCOC
Thallium	0.26 - 0.34	2/11	0.28	0.66	—	JA	71093	0.2	—	mg/kg	
Tin	3.1 - 3.9	4/11	3.1	9.4	—	JA	70993	3.5	630	mg/kg	
Vanadium	0.59 - 0.75	11/11	10	29	—	V	71093	19	91	mg/kg	
Zinc	0.44 - 0.57	11/11	42	84	—	JA	71093	70	68	mg/kg	1
Radionuclides											
Americium-241	0	11/11	-0.00033	0.0095	J	A	70993	0.0030	—	pCi/g	
Cesium-137	0.1	11/11	-0.034	0.015	J	—	70993	-0.0039	—	pCi/g	
Gross alpha	1.9 - 3.4	11/11	5.6	14	—	V	70993	11	—	pCi/g	
Gross beta	2.3 - 2.6	11/11	21	26	—	V	71093	24	—	pCi/g	
Plutonium-239/240	0 - 0.016	8/8	0	0.0074	J	A	71093	0.0034	—	pCi/g	
Radium-226	0.5	11/11	0.91	1.3	—	—	70993	1.1	2.5	pCi/g	
Radium-228	0.5	11/11	1.1	1.6	—	—	70993	1.4	—	pCi/g	
Strontium-89/90	0.04 - 0.05	11/11	0.023	0.87	J	A	71093	0.18	2.6	pCi/g	
Tritium	440 - 450	11/11	-38	310	J	V	70993	80	—	pCi/l	
Uranium-233/234	0.021 - 0.055	11/11	0.74	1.4	—	A	70993	1	—	pCi/g	
Uranium-235	0 - 0.046	11/11	-0.0039	0.11	J	A	70993	0.053	—	pCi/g	
Uranium-238	0 - 0.033	11/11	0.85	1.3	—	A	70993	1.1	—	pCi/g	
Volatile Organic Compounds											
1,1,1-Trichloroethane	6	1/11	2	2	J	A	70993	3	—	µg/kg	3
Toluene	6 - 110	11/11	120	580	—	JA	70993	310	—	µg/kg	3
Indicator Parameters											
% Solids	0.1 - 0.1	11/11	83	89	—	V	71093	87	—	%	
Total organic carbon	0.05	3/11	500	2,600	—	V	71093	700	—	mg/kg	
pH	0.2	11/11	7.6	8.6	—	V	71093	8	—	pH	

**Table A-5. Analytes Detected in Upper Hydrostratigraphic Unit
Groundwater Downgradient of Present Landfill**

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Location of Maximum Detection	Mean	Background UTL _{max} Concentration	Units	PCOC
Metals											
Aluminum	12 - 200	18/20	140	7,200	—	—	53194	1,200	26,000	µg/l	
Antimony	11 - 60	2/20	8	67	—	JA	B207089	17	52	µg/l	1
Arsenic	1.4 - 10	4/20	1	4.7	—	—	53194	1	8	µg/l	
Barium	0.4 - 200	16/20	16	120	—	—	53194	48	310	µg/l	
Beryllium	0.2 - 5	2/20	0.2	1.1	—	—	53194	1	4	µg/l	
Cadmium	1.6 - 5	2/20	1	2.4	B	V	B207089	1	4	µg/l	
Calcium	3.4 - 5,000	20/20	39,000	170,000	—	V	B266789	120,000	150,000	µg/l	1,2,3
Cesium	20 - 1,000	1/18	20	45	B	Y	B206789	68	870	µg/l	
Chromium	1.8 - 10	7/20	1.8	18	—	V	B207089	5	190	µg/l	
Cobalt	1.4 - 50	1/20	2	2.1	—	—	53194	2	44	µg/l	
Copper	1.1 - 25	5/20	2	14	—	—	53194	5	42	µg/l	
Iron	5 - 100	20/20	120	8,400	—	—	53194	1,300	32,000	µg/l	
Lead	0.9 - 5	7/20	1	51	—	—	53194	4	20	µg/l	1
Lithium	1 - 100	20/20	14	230	—	V	B206789	150	180	µg/l	1,2
Magnesium	13 - 5,000	20/20	11,000	45,000	—	V	B206789	34,000	34,000	µg/l	1,2,3
Manganese	0.5 - 15	18/20	2.8	170	—	—	53194	46	640	µg/l	
Molybdenum	2.5 - 200	2/20	2	7.3	B	V	B207089	4	200	µg/l	
Nickel	3.7 - 40	5/20	3	11	B	V	B206789	6	100	µg/l	
Potassium	360 - 5,000	16/20	1,300	6,700	—	V	B207089	3,800	5,200	µg/l	1,2,3
Selenium	5	12/20	1	815	—	JA	B206789	230	130	µg/l	1,2
Silver	2 - 10	4/19	2	11	N	JA	B206789	2	7	µg/l	1,2
Sodium	18 - 5,000	19/19	23,000	470,000	—	V	B206789	220,000	150,000	µg/l	1,2,3
Strontium	0.2 - 200	19/19	410	1,900	—	V	B207089	1,200	1,100	µg/l	1,2
Thallium	2 - 10	3/19	1	3.7	—	—	53194	1	9	µg/l	
Tin	8.9 - 200	4/19	8.9	78	—	—	53194	17	170	µg/l	
Vanadium	1.5 - 50	10/19	2.9	32	B	—	4287	8	71	µg/l	
Zinc	1.1 - 20	14/19	9.1	53	—	JA	B206789	22	180	µg/l	
Radionuclides											
Americium-241	0 - 0.03	23/23	-0.43	0.010	—	A	B207089	-0.015	0.04	pCi/l	
Cesium-134	2.2	1/1	0.64	0.64	—	—	B207089	0.64	—	pCi/l	
Cesium-137	0.74 - 2.4	7/7	-0.50	0.43	J	A	B207089	-0.047	1.1	pCi/l	
Gross alpha	4.8 - 74	2/2	0	19	—	Y	B207089	10	390	pCi/l	
Gross beta	10 - 22	2/2	3.5	13	—	Y	B207089	8	220	pCi/l	
Plutonium-238	0 - 0.014	4/4	0.00082	0.0029	—	—	53194	0.0021	0.047	pCi/l	
Plutonium-239/240	0 - 0.087	25/25	-0.00027	0.009	J	V	B207089	0.002	0.065	pCi/l	

Table A-5. Analytes Detected in Upper Hydrostratigraphic Unit Groundwater Downgradient of Present Landfill

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Location of Maximum Detection	Mean	Background UTL _{95%} Concentration	Units	PCOC
Radium-226	0.096	1/1	0.64	0.64	B	Y	B207089	0.64	1.3	pCi/l	
Strontium-89/90	1 - 1.6	2/2	-0.14	0	-	Y	B207089	-0.07	1.2	pCi/l	2
Tritium	210 - 840	61/61	-160	370	U	-	B207089	66	13,000	pCi/l	
Uranium-233/234	0.36	1/1	2.8	2.8	-	Y	B207089	2.8	150	pCi/l	
Uranium-235	0.25	1/1	0.082	0.082	-	Y	B207089	0.082	5.2	pCi/l	
Uranium-238	0.37	1/1	1.5	1.5	-	Y	B207089	1.5	110	pCi/l	
Semivolatile Organic Compounds											
Bis(2-ethylhexyl)phthalate	10	1/7	3	3	J	A	B206789	3	-	µg/l	4
Volatile Organic Compounds											
1,1-Dichloroethane	0.1 - 10	1/89	0.1	0.3	-	V	0786	2	3	µg/l	4
2-Butanone	10 - 100	1/48	6	6	-	-	53194	9	6	µg/l	4
Benzene	0.1 - 10	3/89	0.1	0.5	J	A	B266889	2	3	µg/l	4
Carbon tetrachloride	0.2 - 10	2/89	0.2	7.1	-	Y	B206889	2	520	µg/l	4
Chloroethane	0.4 - 10	2/90	0.4	3	J	A	0786	4	-	µg/l	4
Ethylbenzene	0.2 - 10	1/90	0.2	0.3	J	A	B206889	2	-	µg/l	4
Methylene chloride	0.1 - 10	11/88	0.1	3.2	B	-	B206889	2	16	µg/l	4
Tetrachloroethane	0.1 - 10	1/90	0.1	0.77	-	Y	B206889	2	44	µg/l	4
Total xylenes	0.5 - 10	1/78	0.5	3	J	A	B206889	3	3	µg/l	4
Trichloroethane	0.1 - 10	1/90	0.1	1.4	-	Y	B206889	2	38	µg/l	4
Toluene	0.1 - 10	2/90	0.1	3	J	A	B206889	2	4	µg/l	4
Indicator Parameters											
Ammonia	30 - 100	5/18	80	210	-	Y	B207089	68	-	µg/l	
Bicarbonate as CaCO ₃	1,000 - 10,000	51/51	38,000	860,000	-	V	0786	330,000	-	µg/l	
Carbonate as CaCO ₃	1,000 - 10,000	10/36	0	12,000	-	V	4087	1,800	-	µg/l	
Chemical oxygen demand	0 - 10,000	22/26	4,800	55,000	-	V	0786	16,000	-	µg/l	
Chloride	200 - 50,000	48/48	12,000	530,000	-	V	B207089	230,000	64,000	µg/l	1,2
Cyanide	5 - 100	1/27	1	5.6	B	V	B207089	7	12	µg/l	
Fluoride	0 - 100	50/50	230	3,400	-	-	4087	870	2,000	µg/l	1,2,3
Nitrate/nitrite	20 - 10,000	64/72	20	190,000	-	V	B206889	25,000	56,000	µg/l	1,2
Orthophosphate	10 - 50	13/21	6	60	-	JA	B207089	19	-	µg/l	
pH	0.1	1/1	7.7	7.7	-	Y	B207089	7.7	-	pH	
Silica	400	15/15	2,600	9,600	-	V	0786	5,500	-	µg/l	

**Table A-5. Analytes Detected in Upper Hydrostratigraphic Unit
Groundwater Downgradient of Present Landfill**

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Location of Maximum Detection	Mean	Background UTL _{99.99} Concentration	Units	PCOC
Silicon	12 - 200	14/15	2,700	22,000	—	—	53194	8,100	63,000	µg/l	
Sodium fluoride	100	1/1	520	520	—	V	B206789	520	—	µg/l	
Sodium sulfate	20,000	1/1	520,000	520,000	—	V	B206789	520,000	—	µg/l	
Solids nonvolatile suspended	5,000	1/1	29,000	29,000	—	JA	B206889	29,000	—	µg/l	
Specific conductivity	1	2/2	3,100	3,100	—	Y	B207089	3,100	—	µmhos/cm	
Sulfate	500 - 250,000	50/50	33,000	19,000,000	—	—	B207089	880,000	610,000	µg/l	1,2
Sulfide	1 - 1,000	2/4	1	73,000	—	—	53194	27,000	—	µg/l	
Total dissolved solids	5,000 - 14,000	51/51	280,000	5,100,000	—	V	B206989	1,500,000	—	µg/l	
Total organic carbon	1,000 - 5,000	29/31	190	22,000	—	V	0786	6,400	—	µg/l	
Total suspended solids	1,000 - 5,000	47/50	4,000	590,000	—	7	B206789	75,000	—	µg/l	

**Table A-6. Analytes Detected in Lower Hydrostratigraphic Unit
Groundwater Downgradient of Present Landfill**

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Location of Maximum Detection	Mean	Background UTL _{99%} Concentration	Units	PCOC
Metals											
Aluminum	12 - 200	6/6	640	2,800	N*	JA	53094	1,600	14,000	µg/l	
Antimony	11 - 60	1/6	11	28	B	JA	4187	18	1,300	µg/l	
Arsenic	1.4 - 10	3/6	1.4	2.5	B	V	53094	2	11	µg/l	
Barium	0.4 - 200	6/6	250	400	—	V	4187	300	1,400	µg/l	2
Beryllium	0.2 - 5	1/16	0.28	0.28	B	V	53094	0	122	µg/l	
Calcium	3.4 - 5,000	6/6	90,000	110,000	—	V	4187	96,000	130,000	µg/l	2,3
Chromium	1.8 - 10	2/6	1.8	61	—	V	4187	14	1,200	µg/l	
Cobalt	1.4 - 50	2/6	1.8	3.1	B	V	4187	2.2	1,200	µg/l	
Copper	1.1 - 25	3/6	2.8	17	B	V	4187	9.4	1,300	µg/l	
Iron	7.3 - 100	6/6	1,100	2,800	N	JA	53094	1,800	18,000	µg/l	
Lead	0.9 - 5	4/6	1	4.4	—	V	4187	2.3	22	µg/l	
Lithium	1 - 100	6/6	83	94	B	V	53094	87	150	µg/l	2
Magnesium	13 - 5,000	6/6	20,000	26,000	—	V	4187	22,000	28,000	µg/l	2,3
Manganese	0.5 - 15	6/6	120	290	—	V	53094	200	620	µg/l	2
Molybdenum	2.5 - 200	5/16	13	24	B	V	4187	17	1,200	µg/l	2
Nickel	3.7 - 40	2/6	8.4	48	—	V	4187	18	1,300	µg/l	
Potassium	360 - 5,000	6/6	5,000	8,500	—	V	53094	7,100	8,800	µg/l	2,3
Selenium	2.6 - 5	2/6	1	3	B	V	4187	1	5	µg/l	
Sodium	18 - 5,000	6/6	420,000	470,000	—	V	53094	440,000	660,000	µg/l	2,3
Strontium	0.2 - 200	6/6	1,100	1,500	—	V	4187	1,200	1,700	µg/l	2
Thallium	4.2 - 10	1/6	1	4.2	B	V	53094	2	11	µg/l	
Vanadium	1.5 - 50	3/6	3.3	13	B	Y	53094	8.7	1,300	µg/l	
Zinc	1.1 - 20	6/6	17	53	E	JA	4187	2.5	1,400	µg/l	
Radionuclides											
Americium-241	0.0034 - 0.011	5/5	0.00087	0.0070	—	V	53094	0.0045	0.072	pCi/l	
Plutonium-238	0.0096 - 0.016	4/4	-0.0037	-0.0012	J	V	53094	-0.0024	—	pCi/l	
Plutonium-239/240	0.0029 - 0.013	5/5	-0.0012	0.0077	J	V	53094	0.0019	0.031	pCi/l	
Tritium	260 - 910	25/25	-170	300	U	V	B207189	27	1,800	pCi/l	
Semivolatile Organic Compounds											
Bis(2-ethylhexyl)phthalate	10	1/6	1	2	J	A	53094	4	—	µg/l	4
Butylbenzyl phthalate	10	1/6	1	1	J	A	53094	4	—	µg/l	4

Table A-6. Analytes Detected in Lower Hydrostratigraphic Unit
Groundwater Downgradient of Present Landfill

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Location of Maximum Detection	Mean	Background UTL _{max} Concentration	Units	PCOC
Volatile Organic Compounds											
Acetone	10 - 100	1/32	7	7	J	A	B207189	8	12	µg/l	4
Methylene chloride	0.1 - 10	8/40	0.1	16	–	V	0886	3	12	µg/l	4
Total xylenes	5 - 10	1/34	1	1	J	A	4187	2	4	µg/l	4
Indicator Parameters											
Ammonia	30 - 100	2/4	100	510	–	Y	4187	170	–	µg/l	
Bicarbonate as CaCO ₃	1,000 - 10,000	37/37	10,000	180,000	–	V	0886	120,000	–	µg/l	
Carbonate as CaCO ₃	1,000 - 10,000	13/29	0	110,000	–	V	B207189	17,000	–	µg/l	
Chemical oxygen demand	5,000 - 10,000	10/10	5,000	37,000	–	V	4187	15,000	–	µg/l	
Chloride	200 - 50,000	35/35	12,000	1,100,000	–	–	4187	590,000	530,000	µg/l	1.2
Fluoride	100	36/36	300	1,700	–	Y	53094	870	2,300	µg/l	
Nitrate/nitrite	20 - 100	34/37	20	2,400	–	V	0886	1,300	4,200	µg/l	2
Orthophosphate	10 - 50	1/9	10	20	–	JA	0886	8.9	51	µg/l	
Silica	400	10/10	2,500	6,200	–	–	0886	3,700	12,000	µg/l	
Silicon	12 - 200	5/5	4,800	9,400	–	JA	53094	6,600	–	µg/l	
Sodium fluoride	100	1/1	650	650	–	V	4187	650	–	µg/l	
Sodium sulfate	10,000	1/1	53,000	53,000	–	V	4187	53,000	–	µg/l	
Solids, nonvolatile suspended	5,000	1/1	140,000	140,000	–	JA	B207189	140,000	–	µg/l	
Specific conductivity	10	2/2	490	3,300	–	Y	4187	1,900	–	µmhos/cm	
Sulfate	500 - 10,000	36/36	6,000	79,000	–	JA	B207189	26,000	990,000	µg/l	
Sulfide	1 - 1,000	2/14	2.7	72,000	–	V	53094	18,000	–	µg/l	
Total dissolved solids	5,000 - 14,000	37/37	230,000	2,000,000	–	V	4187	1,300,000	–	µg/l	
Total organic carbon	1,000 - 5,000	11/13	1,000	4,100	–	Y	0886	2,100	–	µg/l	
Total suspended solids	1,000 - 5,000	35/36	5,000	450,000	–	V	0886	130,000	3,000,000	µg/l	

**Table A-7. Summary of Groundwater Quality Data for
Present Landfill Wells**

Well No.	Geologic Unit	Screened Interval (feet)	Well Location	Analytes Exceeding RFCA Tier II Action Level ^a	Exceedance Date(s)
4087	Alluvium	3.5 – 6.5	Downgradient IMP	U-234 U-238	01/12/00 04/20/00 02/20/01 04/09/01 07/13/01
52894	Alluvium	3.0 – 4.0	Downgradient IMP	U-234 U-235 U-238	05/10/00 09/25/00 07/17/01
B206989	Bedrock	11.8 – 21.3	Downgradient IMP	Lithium Selenium Thallium Tritium Uranium-234 Uranium-235 Uranium-238	01/12/00 05/31/00 06/27/00 11/27/00 03/20/01 07/17/01 10/09/01 01/16/02
597	Alluvium/Bedrock	5.9 – 20.9	PU&D Plume	TCE	01/20/00
30800	Alluvium/Bedrock	2.8 – 21.9	PU&D Plume	TCE	10/24/00
70393	Alluvium	8.0 – 23.0	PU&D Plume	1,1,-DCE Trichloroethene Tetrachloroethane	01/17/00 06/01/00 09/22/00 11/01/00 02/21/01 04/26/01 07/11/01 10/10/01 02/21/02
70493	Bedrock	24.0 – 44.0	PU&D Plume	Thallium 1,1,2,2,-Tetrachloroethane cis-1,3-Dichloropropene Dibromochloromethane Hexachlorobutadiene trans-1,3-Dichloropropene Vinyl Chloride Uranium-234 Uranium-238	01/17/00 05/08/00 07/27/00 10/30/00 01/26/01 04/09/01 10/17/01
2197	Alluvium	5.9 – 10.9	South of Present Landfill	Uranium-234 Uranium-238	07/18/01
70193	Bedrock	22.3 – 37.3	Upgradient IMP	Thallium	10/11/01

^a RFCA establishes cleanup levels, or action levels (ALs), for soils, surface water and ground water. The strategy for groundwater is intended to prevent contamination of surface water by applying EPA's maximum contaminant levels (MCLs) for drinking water, (40 CFR 141.61 and 141.62), as the groundwater action levels. Tier II ALs are equal to the MCLs. See RFCA, Attachment 5, Section 3.0, for details.

Table A-8. Groundwater Quality Analytes and RFCA Exceedances

Analyte	Type	Min	Max	RFCA Tier I	RFCA Tier II	No. Tier II Exceedances	Wells with Tier II Exceedances	Units
Aluminum	Metals	0	974	3,650,000	36,500	0		µg/l
Antimony	Metals	0	2.3	600	6	0		µg/l
Arsenic	Metals	0	2.5	5,000	50	0		µg/l
Barium	Metals	14	105	200,000	2,000	0		µg/l
Beryllium	Metals	0	0.38	400	4	0		µg/l
Cadmium	Metals	0	1.61	500	5	0		µg/l
Calcium	Metals	16,200	552,000					µg/l
Chromium	Metals	0	44.5	10,000	100	0		µg/l
Cobalt	Metals	0	2.36	219,000	2,190	0		µg/l
Copper	Metals	0	16	130,000	1,300	0		µg/l
Fluoride	Metals	0	2.8	400	4	0		mg/l
Iron	Metals	0	680					µg/l
Lead	Metals	0	7.6	1,500	15	0		µg/l
Lithium	Metals	0	2,140	73,000	730	8	B206989 (01/12/00, 05/31/00, 06/27/00, 11/27/00, 03/20/01, 07/17/01, 10/09/01, 01/16/02)	µg/l
Magnesium	Metals	3,140	205,000					µg/l
Manganese	Metals	0	203	172,000	1,720	0		µg/l
Mercury	Metals	0	0.048	200	2	0		µg/l
Molybdenum	Metals	0	6.7	18,300	183	0		µg/l
Nickel	Metals	0	14.1	14,000	140	0		µg/l
Nitrate/Nitrate as N	Metals	0.048	69.4					µg/l
Potassium	Metals	0	18,500					µg/l
Selenium	Metals	0	303	5,000	50	8	B206989 (01/12/00, 05/31/00, 06/27/00, 11/27/00, 03/20/01,	µg/l

Table A-8. Groundwater Quality Analytes and RFCA Exceedances

Analyte	Type	Min	Max	RFCA Tier I	RFCA Tier II	No. Tier II Exceedances	Wells with Tier II Exceedances	Units
							07/17/01, 10/09/01, 01/16/02)	
Silver	Metals	0	2.6	18,300	183	0		µg/l
Sodium	Metals	6,170	747,000					µg/l
Total Dissolved Solids (TDS)	Metals	130	5,200					mg/l
Strontium	Metals	85.8	6,470	2,190,000	21,900	0		µg/l
Sulfate	Metals	12	3,400					mg/l
Thallium	Metals	0	14.8	200	2	5	B206989 (11/27/00, 10/09/01, 01/16/02) 70193 (10/11/01) 70493 (10/11/01)	µg/l
Tin	Metals	0	5.4	2,190,000	21,900	0		µg/l
Vanadium	Metals	0	2.77	25,600	256	0		µg/l
Zinc	Metals	0	66.2	1,100,000	11,000	0		µg/l
Tritium	Radionuclides	-32	8,400	66,600	666	1	B206989 (07/17/01)	pCi/l
Uranium	Radionuclides	0	120					µg/l
Uranium-234	Radionuclides	0	60.5	106	1.06	23	B206989 (01/12/00, 07/17/01, 10/09/01) 70493 (01/17/00, 05/08/00, 07/27/00, 01/26/01, 04/09/01, 10/17/01) 4087 (04/20/01, 02/20/01, 07/13/01) 52894 (05/10/00, 09/25/00) 2197 (07/18/01)	pCi/l
Uranium-235	Radionuclides	0	2.83	101	1.01	7	B206989 (01/12/00, 07/17/01, 10/09/01) 52894 (05/10/00)	pCi/l

Table A-8. Groundwater Quality Analytes and RFCA Exceedances

Analyte	Type	Min	Max	RFCA Tier I	RFCA Tier II	No. Tier II Exceedances	Wells with Tier II Exceedances	Units
Uranium-238	Radionuclides	0	37.2	76.8	0.768	21	B206989 (01/12/00, 07/17/01, 10/09/01) 70493 (01/17/00, 05/08/00, 01/26/01, 04/09/01) 4087 (04/20/01, 02/20/01, 07/13/01) 52894 (05/10/00, 09/25/00) 2197 (07/18/01)	pCi/l
1,2,4-Trichlorobenzene	SVOC	0	4.6	7,000	70	0		µg/l
1,2-DCB	SVOC	0	4.2	60,000	600	0		µg/l
1,4-DCB	SVOC	0	4.5	7,500	75	0		µg/l
Chlorobenzene	SVOC	0	0	10,000	100	0		µg/l
Naphthalene	SVOC	0	5	146,000	1,460	0		µg/l
1,1,1,2-Tetrachloroethane	VOC	0	4.4					µg/l
1,1,1-Trichloroethane	VOC	0	23	20,000	200	0		µg/l
1,1,2,2-Tetrachloroethane	VOC	0	4.2	42.6	0.426	1	70493 (10/30/00)	µg/l
1,1,2-Trichloroethane (TCA)	VOC	0	4.1	500	5	0		µg/l
1,1,2-Trichlorotrifluoroethane	VOC	0	0.57					µg/l
1,1-Dichloroethane	VOC	0	4.2	365,000	3,650	0		µg/l
1,1-DCE	VOC	0	15.2	700	7	18	70393 (01/17/00, 06/01/00, 09/22/00, 11/01/00, 02/21/01, 04/26/01, 07/11/01, 10/10/01, 02/21/02)	µg/l
1,1-Dichloropropene	VOC	0	4.3					µg/l
1,2,3-Trichlorobenzene	VOC	0	4.3					µg/l
1,2,3-Trichloropropane	VOC	0	4.1					µg/l

95

Table A-8. Groundwater Quality Analytes and RFCA Exceedances

Analyte	Type	Min	Max	RFCA Tier I	RFCA Tier II	No. Tier II Exceedances	Wells with Tier II Exceedances	Units
1,2-DCA	VOC	0	3.7	500	5	0		µg/l
1,2-Dibromo-3-chloropropane	VOC	0	4.3					µg/l
1,2-Dibromoethane	VOC	0	4.1					µg/l
1,2-Dichloropropane	VOC	0	4	500	5	0		µg/l
1,3-Dichlorobenzene	VOC	0	4.3					µg/l
1,3-Dichloropropane	VOC	0	4.2					µg/l
2,2-Dichloropropane	VOC	0	4.6					µg/l
2-Butanone	VOC	0	0	2,190,000	21,900	0		µg/l
2-Hexanone	VOC	0	0					µg/l
4-Isopropyltoluene	VOC	0	4.8					µg/l
4-Methyl-2-Pentanone	VOC	0	0	292,000	2,920	0		µg/l
Acetic Acid, 2-Ethylhexyl Este	VOC	1.42	1.42					µg/l
Acetone	VOC	0	0	365,000	3,650	0		µg/l
Benzene	VOC	0	0	500	5	0		µg/l
Benzene, 1,2,4-Trimethyl-	VOC	0	4.7					µg/l
Benzene, 1,3,5-Trimethyl-	VOC	0	4.8					µg/l
Bromobenzene	VOC	0	4.6					µg/l
Bromochloromethane	VOC	0	4.4					µg/l
Bromodichloromethane	VOC	0	3.9	10,000	100	0		µg/l
Bromoform	VOC	0	4.1	10,000	100	0		µg/l
Bromomethane	VOC	0	3.8	5,110	51.1	0		µg/l
Carbon Disulfide	VOC	0	0	365,000	3,650	0		µg/l
Carbon Tetrachloride	VOC	0	4.2	500	5	0		µg/l
Chloroethane	VOC	0	3.8	2,940	29.4	0		µg/l

Table A-8. Groundwater Quality Analytes and RFCA Exceedances

Analyte	Type	Min	Max	RFCA Tier I	RFCA Tier II	No. Tier II Exceedances	Wells with Tier II Exceedances	Units
Chloroform	VOC	0	4.2	10,000	100	0		µg/l
Chloromethane	VOC	0	3.6	655	6.55	0		µg/l
Cis-1,2-Dichloroethene	VOC	0	4.4					µg/l
Cis-1,3-Dichloropropene	VOC	0	3.9	47.3	0.473	1	70493 (10/30/00)	µg/l
Cyclotrisiloxane, Hexamethyl-	VOC	1.3	1.3					µg/l
Dibromochloromethane	VOC	0	4	101	1.01	1	70493 (10/30/00)	µg/l
Dibromomethane	VOC	0	4.2					µg/l
Dichlorodifluoromethane	VOC	0	2.1					µg/l
Ethylbenzene	VOC	0	4.6	70,000	700	0		µg/l
Hexachlorobutadiene	VOC	0	4.1	109	1.09	1	70493 (10/30/00)	µg/l
Isopropylbenzene	VOC	0	4.5					µg/l
Methylene Chloride	VOC	0	4.1	500	5	0		µg/l
n-Butylbenzene	VOC	0	4.9					µg/l
n-Propylbenzene	VOC	0	4.8					µg/l
o-Chlorotoluene	VOC	0	4.5					µg/l
p-Chlorotoluene	VOC	0	4.4					µg/l
sec-Butylbenzene	VOC	0	4.6					µg/l
Styrene	VOC	0	4.7	10,000	100	0		µg/l
Trichloroethene (TCE)	VOC	0	22.6	500	5	11	70393 (01/17/00, 06/01/00, 09/22/00, 10/24/00, 11/01/00, 02/21/01, 04/26/01, 07/11/01, 10/10/01, 02/21/02) 597 (01/20/00) 30800 (10/24/00)	µg/l
tert-Butylbenzene	VOC	0	4.6					µg/l

26

Table A-8. Groundwater Quality Analytes and RFCA Exceedances

Analyte	Type	Min	Max	RFCA Tier I	RFCA Tier II	No. Tier II Exceedances	Wells with Tier II Exceedances	Units
Tetrachloroethene (PCE)	VOC	0	8	500	5	7	70393 (01/17/00, 06/01/11, 09/22/00, 02/21/01, 04/26/01, 07/11/01, 10/10/01, 02/21/02)	µg/l
Tetrahydrofuran	VOC	1.1	1.1					µg/l
Toluene	VOC	0	0	100,000	1,000	0		µg/l
trans-1,2-Dichloroethene	VOC	0	4.3					µg/l
trans-1,3-Dichloropropene	VOC	0	4	47.3	0.473	1	70493 (10/30/01)	µg/l
Trichlorofluoromethane	VOC	0	4.2					µg/l
Vinyl Chloride	VOC	0	4.2	200	2	1	70493 (10/30/01)	µg/l
Xylenes (Total)	VOC	0	13.8	1,000,000	10,000	0		µg/l

Appendix B - Applicable or Relevant and Appropriate Requirements

Requirement	Citation	Type	Comment
CLEAN AIR ACT (CAA), 42 USC 7401 et seq.			
COLORADO AIR QUALITY CONTROL COMMISSION (CAQCC) REGULATIONS	5 CCR 1001 (40 CFR 52, Subpart G)		
• Emission Control Regulations for Particulates, Smokes, Carbon Monoxide, and Sulfur Oxides	5 CCR 1001-3 (CAQCC Reg. No. 1)		
➤ Smoke and Opacity	Section II.A.1	C	Air pollutant emissions from stationary sources (e.g., fuel-fired pumps, generators, and compressors, process vents/stacks) shall not exceed 20% opacity.
➤ Fugitive Particulate Emissions	Section III.D	A	Technologically feasible and economically reasonable control measures and operating procedures will be employed to reduce, prevent, and control particulate emissions.
▪ Construction Activities	III.D.2(b)		
▪ Storage and Handling of Material	III.D.2(c)		
▪ Haul Roads	III.D.2(e)		
▪ Haul Trucks	III.D.2(f)		
• Odor Emissions	5 CCR 1001-4 (CAQCC Reg. No. 2)	C	Regulation No. 2 prohibits the emission of detectable odors from any single source in excess of the air standards.
• Air Pollutant Emission Notices (APEN), Construction Permits and Fees, Operating Permits, and Including the Prevention of Significant Deterioration	5 CCR 1001-5 (CAQCC Reg. No. 3)		
➤ APEN Requirements	Part A, Section II	C	An APEN shall be filed with CDPHE prior to construction, modification, or alteration of, or allowing emissions of air pollutants from, any activity. Certain activities are exempted from APEN requirements per specific exemptions listed in the regulation.
➤ Construction Permits, Including Regulations for the Prevention of Significant Deterioration (PDS)	Part B		

A - Action-Specific ARAR; C - Chemical-Specific ARAR; L - Location-Specific ARAR; TBC - To Be Considered

bb

Appendix B - Applicable or Relevant and Appropriate Requirements

Requirement	Citation	Type	Comment
-------------	----------	------	---------

CLEAN AIR ACT (CAA), 42 USC 7401 *et seq.*

<ul style="list-style-type: none"> ▪ Construction Permits 	Section III	C	Construction permits are not required for CERCLA activities; however, substantive requirements that would normally be associated with construction permits will apply. Also, fuel-fired equipment (e.g., generators, compressors) associated with these activities may require permitting.
<ul style="list-style-type: none"> ▪ Non-Attainment Area Requirements 	Section IV.D.2	A/C/L	Even though CERCLA activities are exempt from construction permit requirements, non-attainment area requirements may apply if emissions of certain pollutants exceed certain threshold limits. The requirements include emissions reductions or offsets, and strict emission control requirements.
<ul style="list-style-type: none"> ▪ Prevention of Significant Deterioration Requirements 	Section IV.D.3	A/C/L	Even though CERCLA activities are exempt from construction permit requirements, PSD requirements may apply if emissions of certain pollutants exceed certain threshold limits. The requirements include strict emission control requirements, source impact modeling, and pre-construction and post-construction monitoring.
<ul style="list-style-type: none"> • Standards of Performance for New Stationary Sources 	5 CCR 1001-8 (CAQCC Reg. No. 6)	A	New Source Performance Standards exist for various types of stationary sources.
<ul style="list-style-type: none"> • Emissions of Volatile Organic Compounds (VOCs) 	5 CCR 1001-9 (CAQCC Reg. No. 7)		
<ul style="list-style-type: none"> ➤ General Requirements for Storage and Transfer of VOCs 	Section III.B	A	Applies to the transfer of VOCs to a tank larger than 56 gallons. In such cases, submerged-fill or bottom-fill techniques must be used.
<ul style="list-style-type: none"> ➤ Disposal of VOCs 	Section V	A	Prohibits the disposal of VOCs by evaporation or spillage.
<ul style="list-style-type: none"> ➤ Storage and Transfer of Petroleum Liquid 	Section VI	A	Regulated storage and transfer of petroleum liquids.

A - Action-Specific ARAR; C - Chemical-Specific ARAR; L - Location-Specific ARAR; TBC - To Be Considered

Appendix B - Applicable or Relevant and Appropriate Requirements

Requirement	Citation	Type	Comment
CLEAN AIR ACT (CAA), 42 USC 7401 <i>et seq.</i>			
<ul style="list-style-type: none"> Control of Hazardous Air Pollutants 	5 CCR 1001-10 (CAQCC Reg. No. 8), 40 CFR 61, Subpart A		This subpart details the general provisions that apply to sources subject to National Emission Standards for Hazardous Air Pollutants (NESHAPs). The provisions will apply to activities that are subject to a NESHAP.
<ul style="list-style-type: none"> National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities <ul style="list-style-type: none"> Standard Emission Monitoring and Test Procedures Compliance and Reporting 	5 CCR 1001-10 (CAQCC Reg. No. 8) 40 CFR 61, Subpart H 61.92 61.93 61.96	C,L C, A C, L	<p>This section establishes a radionuclide emission standard equal to those emissions that yield an effective dose equivalent (EDE) of 10 mrem/year to any member of the public. The site complies by using stack effluent discharge data and empirically estimated fugitive emissions in the dose model CAP88-PC for calculating the EDE to the most impacted member of the public to ensure that it does not exceed 10 mrem/year. Also, the perimeter samplers in the Radioactive Ambient Air Monitoring Program (RAAMP) sampler network are used to verify compliance with the standard.</p> <p>This section establishes emission monitoring and testing protocols required to measure radionuclide emissions and calculated EDEs. This section also requires that radionuclide emissions measurements (i.e., stack monitoring) be made at all release points that have a potential to discharge radionuclides into the air which could cause an EDE to the most impacted member of the public in excess of 1% of the standard (i.e., 0.1 mrem/year).</p> <p>This section requires the Site to perform radionuclide air emission assessments of all new and modified sources. For sources that exceed the 0.1 mrem/year EDE threshold (controlled), the appropriate applications for approval must be submitted to EPA and CDPHE. Additional substantive requirements may apply if the activity requires agency approval.</p>

101

Appendix B - Applicable or Relevant and Appropriate Requirements

Requirement	Citation	Type	Comment
FEDERAL WATER POLLUTION CONTROL ACT (aka Clean Water Act [CWA]), 33 USC 1251 <i>et seq.</i>			
COLORADO BASIC STANDARDS AND METHODOLOGIES FOR SURFACE WATER	5 CCR 1002-31	C	Refer to Attachment 5 to RFCA for surface water action levels and standards.
COLORADO BASIC STANDARDS FOR GROUNDWATER	5 CCR 1002-41	C	Refer to Attachment 5 to RFCA for ground water action levels.
NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM REGULATION <ul style="list-style-type: none"> Storm Water Permit for Construction Activities 	40 CFR 122.26	A/L	
DISCHARGES OF DREDGED OR FILL MATERIAL INTO WATERS OF THE UNITED STATES <ul style="list-style-type: none"> Discharges Requiring Permits 	33 CFR 323.3	A/L	
DOE COMPLIANCE WITH FLOODPLAIN/WETLANDS ENVIRONMENTAL REVIEW REQUIREMENTS <ul style="list-style-type: none"> Floodplain/Wetlands Determination Floodplain/Wetlands Assessment Applicant Responsibilities 	.11 .12 .13	A/L	

Appendix B - Applicable or Relevant and Appropriate Requirements

Requirement	Citation	Type	Comment
MIGRATORY BIRD TREATY ACT, 16 USC 701 <i>et seq.</i>			
TAKING, POSSESSION, TRANSPORTATION, SALE, PURCHASE, BARTER, EXPORTATION, AND IMPORTATION OF WILDLIFE AND PLANTS	50 CFR 10	A/L	Principally focuses on the taking and possession of birds protected under this regulation. Enforcement is predicated on location of the project and time of the year. Current list of protected birds is maintained by the Ecology group.
FISH AND WILDLIFE COORDINATION ACT, 16 USC 661 <i>et seq.</i>			
<ul style="list-style-type: none"> • Purpose • Impounding, Diverting, or Controlling of Waters • Impoundment or Diversion of Waters • Administration; Rules and Regulations • Effects of Sewage and Industrial Waters • Authorization of Appropriations • Penalties • Definitions 	16 USC 661 16 USC 662 16 USC 663 16 USC 664 16 USC 665 16 USC 666 16 USC 666(a) 16 USC 666 (b)	A/L	
NATIONAL HISTORIC PRESERVATION ACT (NHPA), 16 USC 470 <i>et seq.</i>			
<ul style="list-style-type: none"> • Identifying Historic Properties • Assessing Effects of the Activity on the Property • Documentation Requirements • Criteria of Effect and Adverse Effect • Protecting National Historic Landmarks • Historic Properties Discovered During Implementation 	36 CFR 800.4 36 CFR 800.5 36 CFR 800.8 36 CFR 800.9 36 CFR 800.10 36 CFR 800.11	L L L L L L	Obligations are met through the Programmatic Agreement among DOE, the Colorado State Historic Preservation Officer (SHPO), and the Advisory Council on Historic Preservation regarding Historic Properties at RFETS, July 17, 1997.

A - Action-Specific ARAR; C - Chemical-Specific ARAR; L - Location-Specific ARAR; TBC - To Be Considered